Vol. XXI. — No. 1. January 1939.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[ 656. 222.1 ]

# Train speeds and services in 1938,

by LIONEL WIENER,
Professor at the University of Brussels.

## CONTENTS.

Pages.

CHAPTER I.
GENERAL PRINCIPLES.

II. France . . . . . 4
IV. Belgium . . . . . 4
V. The Netherlands (fig. 2) . . . 5
VI. Italy . . . . . 9
XIV. Poland (fig. 3). . . . . 10
XX. Germany (fig. 4) . . . . . 11

CHAPTER II.
RAILCARS.

I. Great Britain . . . . . 14
II. France . . . . . 15
V. The Netherlands (fig. 5) . . . 15
VI. Italy (See chapter I) . . . . 17
VIII. Hungary (fig. 6) . . . . . 17
X. Jugoslavia . . . . . 18
XII. Rumania (fig. 7). . . . . 19
XIV. Poland (fig. 8). . . . . 20
XVI. Denmark . . . . . 21
XVIII. Sweden. . . . . 22
XX. Germany (fig. 9). . . . . 22
XXI. Europe. . . . . 26

CHAPTER III.
ELECTRIC TRACTION.

I. Great Britain . . . . . 26
II. France . . . . . 27
V. The Netherlands (see Chapter I) 27
VI. Italy . . . . . 28
IX. Switzerland (fig. 10) . . . . 28
XVIII. Sweden. . . . . 30
XX. Germany . . . . . 30
XXI. Europe. . . . . 31

CHAPTER IV.
STEAM TRACTION.

I. Great Britain . . . . . 33
Ib. Ireland . . . . . 37
II. France . . . . . 38
IV. Belgium (see Chapter I) . . . 39
V. The Netherlands . . . . . 39
VI. Italy (See chapter I) . . . . 39
VIII. Hungary . . . . . 39
XIVb. The Baltic States (fig. 11) . . 39
XX. Germany . . . . . 40
XXI. Europe. . . . . 45

CHAPTER V.
SPECIAL SERVICES.

A. The *International Sleeping Car Co.* 45
B. The *Mitropa* . . . . . 46
C. The British *Pullman Co.* . . . . . 47
D. The *Swiss Restaurant-Car Co.* . . . 47
E. Railway Companies' sleeping- and dining-car services . . . . . 47
F. Train ferries . . . . . 47

CHAPTER VI.
CONCLUSIONS AND COMPARATIVE RESULTS.

*(a)* Fastest European runs . . . . . 50
*(b)* Longest non-stop European runs. . 50
*(c)* Percentages of each system having runs at various speeds . . . . 53

We have previousy published, in the *Bulletin of the International Railway Congress*, a serial dealing with « Train Speeds and Services » in each European country (1). So as to appreciate them at their proper value it has been necessary to study each country's economic and geographical conditions, thus showing what has been done to date and what is the likely trend of future development. Train speeds and services can thus be appreciated and their proper place in the complex of railway economics, grasped.

Each country's accomplishment is the combined outcome of technical progress and of local conditions. As methods of traction are altering daily in relation to each other, throwing the entire railway structure into the melting pot, such a review of Europe's general characteristics had become indispensable. This is also the reason why an annual survey serves a useful and practical purpose.

We give heareafter, in the same order as in our previous annual surveys, information concerning present-day operation and we apportion it between the various kinds of traction : Diesel, electric, and steam. Chapter V shows how fast services are divided between them as also the percentage of each system worked at various non-stop average speeds.

This could have been done in one of two ways. The total number of train-miles run at these speeds could have been tabulated or else the mileage covered at these speeds could be considered. Most of our British contemporaries have taken the former outlook, whereas we have adopted the latter because it seems to show actual progress in all the railway's departments to better advantage. An example will make this clear. An extra hundred miles run at 60 m.p.h. average speed may accrue either, as in the English system, because an extra train has been placed on a route where a number of others already ran at this speed (say a 50th train on a line previously having 49) or because 100 miles

---

(1) We give hereafter an alphabetical list of these countries and reference to the number of the *Bulletin* and to the page on which each subject is treated. We have added, between brackets, the page of the reprint in book form.

We have retained for each country, the serial number which was attributed to it in the serial and shall keep to the same numbers in this and future articles.

VII. Austria — May 1935, p. 493 (435).
IV. Belgium — February 1935, p. 141 (281).
XI. Bulgaria — March 1936, p. 297 (565).
XIII. Czechoslovakia — March 1936, p. 325 (593).
XVI. Denmark — June 1936, p. 631 (609).
XV. Finland — May 1936, p. 513 (625).
II. France — May and June 1934, pp. 407 and 561 (151 and 205).
XX. Germany — August and October 1937, pp. 1 707 and 2 005 (737 and 817).
I. Great Britain — November 1933 and January 1934, pp. 1 027 and 63 (45 and 119).
VIII. Hungary — May 1935, p. 527 (469).
I*b*. Ireland — January 1934, p. 91 (147).
VI. Italy — April 1935, p. 385 (393).
X. Jugoslavia — March 1936, p. 281 (549).
V. Netherlands — March 1935, p. 275 (363).
XVII. Norway — July 1936, p. 667 (663).
XIV. Poland — May 1936, p. 491 (603).
XIX*b*. Portugal — See « Spain ».
XII. Rumania — March 1936, p. 308 (576).
XIV*b*. Russia — May 1936, p. 506 (618).
XIX. Spain — February 1937, p. 479 (715).
XVIII. Sweden — August 1936, p. 769 (667).
IX. Switzerland — July and October 1935 pp. 817 and 1 201 (485 and 525).
XI*b*. Turkey — March 1936, p. 304 (572).

**General.**

XXI. Europe in 1937 — November 1937, p. 2 101 (855).
III. The *International Sleeping-Car Co.*, July 1934, p. 653 (229).

of railway where no train previously reached this standard now has one running at this speed. In the former instance, an extra train among a series of others is placed at the public's disposal; in the latter, there is a faster train between two places than had previously been the case. In both instances, the Traffic and Locomotive Departments have had to maintain the same standard; but in the latter, the Permanent Way Department has had to improve one hundred extra miles of railway. And whereas in our system, this is taken into account, it is not in the other.

We also contend that it has the appreciable advantage of enabling inter-system comparisons to be made and to show the percentages of each of them covered by the fastest trains at various speeds; this is more comprehensive than percentage of one section's to total train-miles as this may give an erroneous idea of the technical standard of the system if they all occur (as actually does happen abroad) over one or very few of the Railway Company's lines.

All fast trains over every railway in Europe have to be looked up and tabulated but in spite of the work entailed, the resulting percentages constitute so important a factor of appreciation that they are worth establishing. All these calculations thus boil down to the few items contained in Tables 22 and 23 which show at a glance the actual railway speed standards in each country and render them comparable not only with each other but also show progress (or the reverse) from year to year (1).

TIMETABLES. — We have used the 1938 summer official timetables; where needful, we have corrected the mileage as the timetables frequently show virtual tariff-mileages instead of actual distances. This occurs in France, Denmark, Austria, Hungary, Switzerland, Bulgaria, etc.

TABLES. — As previously, we have applied the following rules :

*(a)* Items concerning non-stop runs are shown in heavy type;

*(b)* Those applying to obsolete runs or to runs that do not actually fall under the heading of the table but which it is nevertheless advisable to quote, are printed in italics;

*(c)* In the columns showing the runs, places whose name appears between brackets lie outside the actual run. They are quoted to show where the trains come from or go to, and to what through journey the run belongs.

ILLUSTRATIONS. — In our « cartograms of train speeds » we have conventionally designated by different kinds of lines, the sections of each system having va-

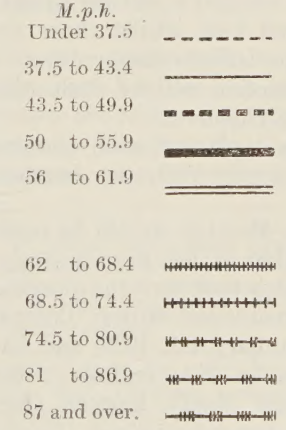



Fig. 1. — Reference of the cartograms, showing average speeds.

(1) See those applying to 1933 in the *Bulletin* for October of that year, p. 921 (37) and those of 1937, in the *Bulletin* for November, p. 2125 (841).

rious maximum (non-stop) average speeds. As all illustrations of our previous and future articles are so shown, figure 1 reproduces a common Reference for them all.

## CHAPTER I.

### High-speed railway services.

The actual organisation of these services is based upon principles which have been altered in several countries such as Belgium, where the former « bloc » or set-trains have disappeared and more especially in the Netherlands, where changes of such magnitude have taken place that they might almost be termed revolutionary. Italian « rapidi » services have been overhauled and extended, whereas the Berlin-Vienna communications have been adapted to the new traffic conditions resulting from the Anschluss. Lastly Polish-Lithuanian through connections which had been in abeyance since 1920, have been re-established. These points having a general bearing on the country's railway system will be examined here whilst those applying more especially to one or other of the modes of traction will be dealt with in the following chapters.

As previously explained, each country is listed with its own reference number.

II. **France.** — Mention should be made of the constitution of the *French National Rys. Co.* which took over the working of the former main-line railway Companies as from January 1st, 1938, and has regrouped them in five regions : the Northern (former *Nord*), Eastern (former *Est* and *Alsace-Lorraine)*, South-Eastern (former *P. L. M.*), South-Western (former *P. O.-Midi*), and Western (former *Etat*). The total mileage is 26 440 (42 706 km.).

The working of the Paris (Luxembourg)-Palaiseau line of the former *P.O.* has been taken over by the *Metropolitan Ry.* (1). The new line from Saint-Dié to Sainte-Marie-aux-Mines and Sélestat is opened to traffic from end to end, but no important services are run over it (2).

IV. **Belgium** was the first to run, under the name of « trains-blocs », fast lo-

---

(1) There are 9 km. (5.6 miles) to Bourg-la-Reine, and 17 km. (10.6 miles) altogether to Massy-Palaiseau. The branch from Bourg-la-Reine to Sceaux is 2.6 km. (1.6 miles) long.

As we have previously given some information concerning the former broad-gauge lines of the Continent, the following items may be of interest.

This small independent system was built from Paris (Montrouge) on the Arnoux system to a 1.75 m. (5' 9") gauge. The articulated rolling stock traversed curves of very small radius : 50 m. (164') radius on the open line and 25 m. (82') only for the terminal loops. The line was opened from Paris (Montrouge) to Sceaux on the 23rd June, 1846, and a branch (which was later to become the main line), from Bourg-la-Reine to Orsay, on the 29th August, 1854. Owing to financial difficulties, the Government obliged the *P. O. Ry. Co.* to take over the system in 1857, and to extend it to Limours, 24 km. (14.9 miles) beyond Massy-Palaiseau, which was done in 1867. The total mileage thus reached 24.7 (39.79 km.).

In 1883, the *P. O. Co.* was enjoined to reduce the gauge to standard. An underground extension into Paris, 1.5 km. (0.9 mile) long was opened from Montrouge to the present Luxembourg terminus in 1895.

The through *Metropolitan Ry.* electric trains now take 15 minutes for the 10 1/2 miles and 25, with 11 stops. They are to have running powers over the *P. O.*'s line from Massy-Palaiseau to Saint-Remy, a distance of 16 km. (10 miles) upon completion of this section's electrification.

(2) The Chaumes de Lusse tunnel, 6.872 km. (4.27 miles), is the longest in France.

The highest point, 438.58 m. (1 439') above datum, is reached by means of an easy gradient of 1 in 100 along the first 935 m. (1 023 yards) of the tunnel. The line then falls at the rate of 1 in 70 until the Eastern portal, which is at 353.84 m. (1 161') above sea level.

cal set-trains between important towns. Owing to ever-increasing patronage, extra carriages have been coupled on to such an extent that as from May 1st 1938, these trains have been permanently lengthened and are no longer limited. Most of them now only have 2nds and 3rds. As they frequently run to 12 cars and more, weighing up to 600 tons, which can no longer be considered a light train, some of the timings have been eased out to reduce the costs of haulage.

A minute or so has been added on short runs; whilst having but little influence on total timings, this has lowered average speeds which remain notable in a number of cases. The Brussels-Ostend standard timed trains again run, whilst the new Bruges bye-pass station is being finished, through the old Bruges-Town station. The fastest of these take 1 h. 13 m. from Brussels to Ostend with two stops on the way and cover the 43 km. (26.7 miles) from Ghent to Bruges in 23 minutes at 106.9 km. (66.4 miles) an hour, which obliges them to run most of the way at 140 km. (87 miles) per hour. The non-stop Brussels-Ostend trains are still the fastest in the country and rank between the *L. and N. E.* and the *L. M. and S.*'s best; a novelty has been the introduction of Brussels Midi-Blankenberghe and Brussels Midi-Heyst non-stop trains at 59.7 and 58.77 m.p.h., a notheworthy performance as neither of the branches beyond Bruges allow of high-speed running.

Last winter's timetables listed two couples of fast Brussels and Ostend trains either way, which were to run since February 1st, 1938, and take exactly one hour for the 114 km. (70.8 miles), in spite of a stop at Bruges. A small extra seat fare was to apply as in most countries' special high-speed trains, such as the British streamlined ones (1). But official authorisation having been withheld, the Company has not put the trains on. This way of looking at things is justifiable but it raises a number of questions which are outside the scope of this paper. We should add, however, that supplementary fares have formerly been paid for occupying seats in fast expresses such as the « Ostend-Cologne » or even for entering the dining cars. But then, they were paid to the railways when they were State Rys. and not Company-operated.

Standardisation of train schedules has been further extended to semi-fast trains of the Mons, Charleroi, Namur and other lines.

But the usual insidious appearance of intermediate stoppages has happened here as elsewhere, and Belgium has been no more immune from this mishap than any other country. Thus there is no longer any non-stop train between Brussels and Courtrai whilst formerly there were four either way.

V. **The Netherlands.** — The working agreement between the two Dutch Companies, the *Holland Ry. Co.* and the *Company for Working the State Rys.*, having matured, the *Netherlands Rys. Co.* has

---

(1) These extra fares apply in Great Britain both to all-Pullman trains and others.

There was an extra seat fare of 2 sh. 6 d. on the *Gt. Western Ry.*'s Birmingham and Cardiff railcars.

On the *L. M. and S. Ry.*, there are supplementary fares for travelling on the « Coronation Scot »; these amount to 2 sh. 6 d. between London Carlisle, or Glasgow, both in 1st or in 3rd class.

On the *L. and N. E. Ry.*, the supplement on both the « Coronation » and on the « Silver Jubilee » is 6 sh. and 4 sh. between London and Edinburgh according to class. Lower fares apply between other places. Besides this, an extra shilling is paid for one hour's occupation of a seat in the observation car.

formally taken over the operation of all lines as from January 1st, 1938. Modernisation of the working had begun a few years ago and has been continued, and co-ordination of all means of transport has been pushed one step further.

Drastic changes have occurred and the new timetable which has been put into force last May embodies a number of new principles entailing far reaching results which previous experience had sanctioned. Non-paying or useless lines have been closed down either to all or to passenger traffic whereas others are still the subject of careful study. This is the outcome of experiments started as far back as 1936, when all intermediate stations on the 29 km. (18 miles) Zwolle-Deventer line had been closed down. Local traffic was transferred to a motor-bus Company whose services connected with the railway's at Zwolle and Deventer. It soon appeared that not only did intermediate stations not suffer from the change, but that they had more frequent services than formerly, and that through traffic between Zwolle and Deventer increased.

Further extending the same principle, slow trains have been withdrawn from other lines thus giving greater freedom for the running of fast trains; this experiment also has been successful. This being so, the 860 stations open to passengers in 1926 were brought down to 560 in May 1936, and 148 others were closed last May bringing the present number down to 412 (fig. 2). During the same period (1926 to 1938), passenger traffic has been suppressed on 435 miles of Dutch railways.

Handing local passengers to the motor-buses was but one step in the programme of coordination : the Railways intended taking them back at the stations where their expresses stopped and to accomplish this, rail travel has been made desirable and pleasing. New rolling stock has been acquired : clean dust-proof electric trains with all modern comforts and gadgets, diesel cars to be worked singly or in multiple-units. Owing to their high acceleration, these trains have fast timings even over short distances. To accomplish this, speed-limits have been raised as under :

Fig. 2 (*). — Dutch railway stations closed to passenger traffic since May 15th, 1938.

| | Km./h. | M.p.h. |
|---|---|---|
| New electric trains . . . | 120 | 74.6 |
| Old electric trains . . . | 100 | 62.1 |
| Diesel streamlined trains . | 120 | 74.6 |
| Single railcars over main lines. . . . . | 90 | 55.9 |
| Single railcars on branches | 75 | 46.6 |
| Steam trains . . . . . | 100 | 62.1 |

In practice the timings of the trains have actually been drawn up at these speed limits and the time spent for stops

(*) Figures 2 and 3 have been reproduced from *The Railway Gazette*.

or lost in deceleration and accelerating, tagged on.

In practice, it has been found that the acceleration of the streamlined electric trains is much higher than that of the diesel multiple-unit trains; it is 160 p.c. greater at the lower speeds and 60 p.c. at the higher. On the other hand, retardation is identical. The acceleration of the old electric non streamlined stock is slower, but still quicker than the diesel's, but in this case deceleration is slower.

The acceleration of streamlined railcars is not as great as the streamlined sets', but deceleration is the same. We reproduce actual figures contained in a table published by the *Railway Gazette* and we are indebted for most of the other items to the *Netherlands Ry. Co.*

Electrification has progressed from 235 to 510 km. (146 to 317 miles), the South and North services between Dordrecht, Amsterdam and Alkmaar being unchanged.

Both the electric double- and triple-car sets seating 120 and 192 respectively can be worked as multiple-units. Their maximum speed in actual service reaches 125 km. (77.6 miles) an hour, though they touched 150 km. (93 miles) during test runs. It takes 60 seconds to reach a speed of 60 miles an hour and 120, to reach 75 miles.

We have previously given similar information concerning the diesel sets.

Standardised timings have been extended, trains running at regular hourly or half-hourly intervals. So as to maintain this regularity throughout the day, the timings of other interfering trains such as international expresses have been sacrificed, when need be. But owing to the nature of the country, it

TABLE 1.

ADDITIONAL TIME ADDED TO NETHERLANDS RYS. START-TO-STOP TRAIN TIMINGS SO AS TO TAKE ACCELERATION, RETARDATION AND STOPS INTO ACCOUNT.

| CLASS OF TRAIN. | Maximum speed | | Additional time (in minutes) for | | Total time (acceleration and retardation). | |
|---|---|---|---|---|---|---|
| | Km./h. | M.p.h. | Acceleration. | Retardation. | In minutes and decimals. | In seconds. |
| Electric, streamlined . . . . | 120 | 75 | 0.69 | 0.62 | 1.31 | 79 |
| Diesel, streamlined. . . . . | Do. | Do. | 1.24 | 0.62 | 1.86 | 112 |
| Electric, streamlined . . . . | 100 | 62 | 0.48 | 0.52 | 1.00 | 60 |
| Electric, non-streamlined . . | Do. | Do. | 0.80 | 0.64 | 1.44 | 86 |
| Diesel, streamlined. . . . . | Do. | Do. | 0.84 | 0.52 | 1.36 | 82 |
| Electric, streamlined . . . . | 90 | 56 | 0.41 | 0.48 | 0.89 | 53 |
| Electric, non-streamlined . . | Do. | Do. | 0.62 | 0.58 | 1.20 | 72 |
| Diesel, streamlined. . . . . | Do. | Do. | 0.70 | 0.48 | 1.18 | 71 |
| Railcar, streamlined . . . . | Do. | Do. | 1.36 | 0.48 | 1.84 | 110 |
| Steam, light train . . . . . | Do. | Do. | ... | ... | 2.00 | 120 |
| Steam, average train . . . . | Do. | Do. | ... | ... | 3.00 | 180 |

TABLE 2.

NOTEWORTHY DUTCH TRAIN RUNS.

Non-stop runs are shown in **heavy** type.

| RUN. | Distance. | | Time of departure. | Time spent. | Speed. | | Number of stops. | — |
|---|---|---|---|---|---|---|---|---|
| | Km. | Miles. | | | Km./h. | M.p.h. | | |
| **Electric traction.** | | | | | | | | |
| Amsterdam W.P. (1)-Utrecht-Arnhem | 91.9 | 57.2 | 6.43 a.m. | 1.01 | 90.6 | 57 1 | 3 | Standard tra |
| Amsterdam W.P.-Utrecht C.S. (2). | 35.0 | 21.7 | Do. | 0.21 | 99.9 | 62.1 | ... | Do. |
| Driebergen-Ede Wageningen | 28.8 | 17.9 | 7.17 a.m. | 0.16 | 108.2 | 67.2 | ... | Do. |
| Ede Wageningen-Arnhem | 16.5 | 10.3 | 7.34 a.m. | 0 10 | 99.0 | 61.5 | ... | Do. |
| The Hague-Utrecht-Eindhoven | 139.8 | 86.9 | 6.14 a.m. | 1.56 | 72.6 | 45.1 | 9 | Standard tra |
| Voorburg-Gouda | 25.3 | 15.7 | 6 18 a m. | 0 16 | 95 0 | 59 0 | ... | Do. |
| Rotterdam M.-Gouda | 20.4 | 12.7 | 6.23 a.m. | 0.14 | 87.0 | 54.1 | ... | Do. |
| Culemborg-Geldermalsen | 7 8 | 4.8 | 7.23 a.m. | 0.05 | 93.2 | 57.9 | ... | Do. |
| s'Hertogenbosch-Boxtel | 12.2 | 7.6 | 7.48 a.m. | 0.08 | 91.5 | 56 8 | ... | Do. |
| Boxtel-Eindhoven | 19.9 | 12.4 | 7.57 a.m. | 0.13 | 91.9 | 57.1 | ... | Do. |
| Amsterdam C. S.-Alkmaar | 38.9 | 24.2 | 9.17 a.m. | 0.29 | 80.4 | 50.0 | 3 | Standard tra |
| Amsterdam C. S.-Dordrecht | 105.3 | 65.4 | 7 13 a.m. | 1.29 | 71.0 | 44.1 | 7 | Standard tra |
| Haarlem-Leiden | 28.8 | 17.9 | 7.29 a.m. | 0.19 | 91.0 | 56.5 | ... | Do. |
| Leiden-The Hague | 15.4 | 9.6 | up 5.59 a.m. | 0.10 | 92.4 | 57.4 | ... | Do. |
| Amsterdam-The Hague | 62.7 | 39.0 | up 8 15 a.m. | 0.43 | 87.5 | 54.4 | 1 | Train 102 |
| Hook Harbour-Schiedam (Rotterdam) | 23.0 | 14.3 | 6.29 a.m. | 0.16 | 86.2 | 53.6 | ... | Boat train |
| **Diesel trains.** | | | | | | | | |
| Amsterdam C. S.-Groningen | 221.0 | 137.3 | 6 17 a.m. | 2 25 | 91.5 | 56 9 | 5 | Standard EM train |
| Amersfoort-Zwolle | 66.8 | 41.5 | 6.55 a.m. | 0.38 | 105.5 | 65.6 | ... | Do. |
| Zwolle-Meppel | 27.4 | 17.0 | 7.36 a.m. | 0.17 | 96 7 | 60.1 | ... | Do. |
| Meppel-Hoogeveen | 19.8 | 12.3 | 7.54 a.m. | 0.12 | 99.1 | 61.6 | ... | Do. |
| Hoogeveen-Assen | 29 5 | 18.3 | 8.07 a.m. | 0.17 | 104.5 | 64.9 | ... | Do. |
| Assen-Groningen | 27.5 | 17.1 | 8.25 a.m. | 0.17 | 97.3 | 60.5 | ... | Do. |
| The Hague-Amersfoort-Oldenzaal. | 203 9 | 126 7 | 5 47 a.m. | 2 44 | 74.6 | 46.4 | 9 | Standard EM train |
| Voorburg-Gouda | 25.3 | 15.7 | 5 51 a.m. | 0.16 | 95 0 | 59 0 | ... | Do. |
| Utrecht C. S.-Amersfoort | 21.0 | 13.0 | 6.38 a m. | 0.13 | 97.0 | 60.3 | .. | Do. |
| Amersfoort-Apeldoorn | 43 6 | 27.1 | 6.58 a.m. | 0.26 | 100.3 | 62.3 | ... | Do. |
| Hengelo-Oldenzaal | 10 8 | 6.7 | 8.23 a.m. | 0.08 | 81.0 | 50.3 | ... | Do. |
| Hengelo-Enschede | 8 1 | 5.0 | 8 20 a m. | 0.07 | 69.4 | 43.1 | ... | Do. |
| Rotterdam Maas-Gouda | 20.3 | 12.6 | 5 55 a.m. | 0 15 | 81.2 | 50.5 | ... | Do. |
| Amsterdam W. P. (1)-Eindhoven-Maastricht. | 215 | 133.6 | 5 39 a.m. | 2.42 | 77.2 | 48.0 | 10 | Standard EM train |
| Nieuwersluis-Utrecht C. S. | 15.7 | 9.8 | 5.53 a.m. | 0.11 | 85.6 | 53 2 | ... | Do. |
| Utrecht-Eindhoven | | | As for electric trains. | | | | | |
| Eindhoven-Weert | 18.9 | 18.2 | 7.15 a.m. | 0.18 | 96.6 | 60 2 | ... | Do. |
| Weert-Roermond | 24.1 | 15.0 | 7.34 a.m. | 0.15 | 96.4 | 59 9 | ... | Do. |
| Roermond-Sittard | 24.5 | 15.2 | 7.51 a.m. | 0.16 | 91.9 | 57.1 | ... | Do. |
| **Steam traction.** | | | | | | | | |
| Flushing-Tilburg | 121.0 | 75.2 | 6.08 p. m. | 1.31 | 78.7 | 48.9 | ... | ... |
| Amersfoort-Almelo-Hengelo | 111.5 | 69.2 | 9.31 a.m. | 1.30 | 74 3 | 46.2 | ... | Hook-Berli |
| Amersfoort-Zwolle | 66.8 | 41.5 | 7.47 p.m. | 0.45 | 89.1 | 55.4 | ... | Standard tra |

(1) These trains come from Amsterdam C. S., a distance of 5.704 km. (3.54 miles).

(2) The distance from Rotterdam D. P. to Rotterdam Maas is 13.622 km. (8.5 miles), and that fro Rotterdam D. P. to Rotterdam Beurs, 1.574 km. (0.98 mile).

was no easy matter to determine which communications should have through trains and which, simply connections. Holland's three large western towns, Amsterdam, The Hague, and Rotterdam, are properly inter-connected by electrified lines, but good services to all other important places inland were to be available from each, for both Utrecht and Amersfoort. Not only are these important passing stations but they are also railway centres from which a number of lines radiate.

Besides this, mixed working by the various kinds of traction has been maintained; diesels run over the electrified lines beyond and steam-hauled heavy international or other trains have to be fitted in, no easy matter as they run at lower speed.

Thus trains hailing from Amsterdam on the one hand, from The Hague and Rotterdam on the other (these having joined up at Gouda) run through Amersfoort or Utrecht, where they are tangent, the Amsterdam-Amersfoort trains mostly continuing along a more northerly line than the Hague-(Rotterdam)-Utrecht ones. The reverse also occurs for some of them. But, so that the three Western towns should have convenient connections by all the trains to all places beyond Utrecht and Amersfoort, they are all timed with a 6-minute stop in Utrecht which allows plenty of time to change.

Whereas the old electric trains of Western Holland still carry three classes of passengers as do all long-distance through trains, both the diesels and the new electric trains only carry two (second and third), as has long been the practice on the branches.

In Table 2, we have shown all interesting runs grouped according to kind of traction. We have quoted the end-to-end runs, with timings and overall speed. Whereas stops at most stations are short and the trains sprint between them, those at important junctions such as Utrecht and Amersfoort are more lengthy. In spite of this, overall averages are high.

We have quoted as usual, immediately below each through run, and in heavy type, the principal characteristics of non-stop runs. There is little enough to choose between the electrically operated and the diesel trains, but attention should be drawn to the high speed maintained even over the shorter runs and which call for a very high standard of operation. It should be remembered however, that gradients are mostly negligible.

VI. Italy. — « Rapidi », whether steam, electric or diesel, are gradually appearing on all lines of any importance. Most of them are extra-fare trains.

New railcar services now connect Turin with Milan, and Naples with Foggia and Bari, on the opposite coast. Since several years, railcar « rapidi » run over the whole of Sicily and have now appeared in Sardinia as well, beginning with the Terranova-Cagliari main artery. They connect at the former place, with the Civitavecchia mail-packets, thus considerably shortening the overall journey from Rome to Cagliari (fig. 12).

On the other hand, the Milan and Venice railcars have been withdrawn and steam-hauled « rapidi » alone run. This is the second time deceleration has taken place on this route. It will be remembered that the overall timing had to be increased from 2 h. 40 m. to 2 h. 44 m. (1)

(1) See the *Bulletin* for July 1937, p. 2 112 (866).

and now again to 2 h. 55 min. including intermediate stops at Verona and Padua.

Electrification is continually being extended, the next lines to be opened to electric traffic being those from Rome to Pisa along the western shore and of Milan to Bologna and Ancona on the eastern. It is expected this will take place on November 14th, 1938, when considerable acceleration is looked forward to.

New possibilities have been opened out by ultra high-speed test trains of which more hereafter.

Table 3 shows all Italian services run at over 62 miles (100 km.) an hour by railcars, electric and steam traction.

TABLE 3.

ITALIAN LINES WITH AVERAGE SPEEDS OVER 100 KM. (62 MILES) AN HOUR.

| RUN. | Distance. | | Time of departure. | Time spent. | Speed. | |
|---|---|---|---|---|---|---|
| | Km. | Miles. | | | Km./h. | M.p.h. |
| **Railcars.** | | | | | | |
| Turin P. S.-Milan Cent. . . . . | 147 | 91.3 | 6.38 a. m. | 1.24 | 105.0 | 65.2 |
| (Bolzano) Trento-Rovereto (Bologna) . | 24 | 14.6 | 8.40 a. m. | 0.14 | 102.8 | 62.5 |
| **Electric traction.** | | | | | | |
| Bologna C.-Florence S. M. N. . . . . | 97 | 60.3 | 4.04 p. m. | 0.52 | 111.9 | 69.5 |
| Florence S. M. N.-Rome Termini. . . | 316 | 196.3 | 5 01 p. m. | 3.07 | 101.4 | 63.0 |
| Rome Termini-Naples Mergellina. . . | 210 | 130.5 | 8.14 p. m. | 1.49 | 115 6 | 71.8 |
| *Ditto (On July 27th, 1938, only).* . . | *Do.* | *Do.* | ... | *1.30* | *140.0* | *87.0* |
| **Steam traction.** | | | | | | |
| (Milan) Verona-Padua (Venice) . . . | 83 | 51.3 | 9.54 a. m. | 0.49 | 101.6 | 62.8 |

XIV. **Poland.** — It will be remembered that after Poland occupied Wilno and a large band of the Lithuanian territory in 1920, all railway communication over the former border was suspended. Lithuania even dismantled the four through lines on its own side of the new frontier over a distance which varied from 2 to 14 km. (1 to 9 miles). Five miles of the main line from Kaunas to Wilno (99 km. = 61.5 miles), which was a portion of the international railway to Minsk and Moscow, were dismantled beyond Vievis, up to the present frontier. The Kozlu-Ruda branch thence-forward stopped at Artilerija, 2 miles from the new border whereas the 25 km. (15.5 miles) sub-branch from Sestokai to the frontier station of Trakiszki was definitely suppressed. The gauge of the fourth line was 75 cm. (2' 5 1/2") only.

At the same time, Poland acquired 1 108 km. (689 miles) of broad gauge and 176 km. (109 miles) of narrow-gauge lines. The main line from Warsaw to Leningrad entered the annexed territory between Sokolka and Kuznica (former frontier stations) and after passing through Wilno, Lithuania's former capital, reached the new northern frontier at Zemgale, 341 km. (222 miles) away.

In compliance with Poland's recent ultimatum, Lithuania undertook to re-

establish rail communication by March 31st, 1938. This was done, with a slight delay and the running of new international trains can now be expected.

In Poland proper, the new through Warsaw-Krakow line via Kielce has been open to traffic for some time past and traffic has been diverted to it from the more westerly Czestochova route which it previously followed. The distance has thus been brought down from 364 to 320 km. (226 to 199 miles).

XX. Germany. — The *Reichsbahn*'s system has been enlarged by the inclusion of the *Lubeck-Büchen Ry. Co.*'s 161 km. (100 miles) of standard- and 29 km. (18 miles) of secondary railway lines (1) which have been taken over as from January 1st, 1938, and later by those of the *Munich Local Rys. Co.* which previously operated 169 km. (105 miles) of standard-gauge lines. The former was, at the time, the most important private railway in the Reich.

Since then, a further mileage has been ceded to Germany by Czechoslovakia, but this has taken place after the Summer of 1938 and will be dealt with next year.

Generally speaking, whereas the number of fast runs increases from year to year, the fastest of them, whether accomplished by diesel railcars, by the Bavarian electric locomotives or by steam traction, have been decelerated in 1937 and again in 1938. This is mainly due to the fact that since 1935, so great has been the increase in traffic, that the weight of the trains has risen abnormally, thus rendering acceleration more difficult; at the same time, the large number of passengers to be dealt with at the stations has caused a loss of time. Not only have the trains been decelerated but alleviation sought in another direction as well : in many instances, instead of adding through cars or rakes on the way, these have continued independently to destination, though this has increased train mileage by 25 p.c. as compared with 1937.

Owing to its 132.3 km. (82.2 miles) an hour run, the « Fliegende Kölner »

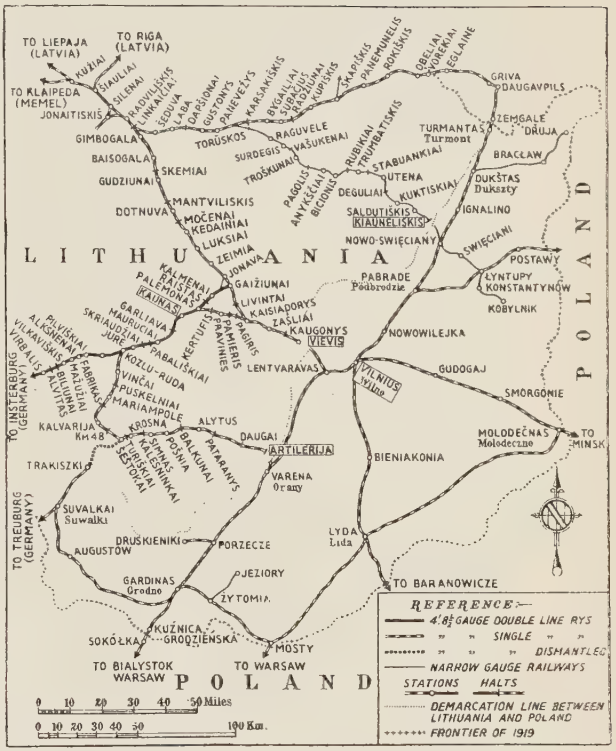



Fig. 3 (*). — Polish-Lithuanian frontier railway sections dismantled along the frontier.

(1) See *Bulletin*, August 1937, p. 1 709 (739).

(*) This illustration is reproduced from *The Railway Gazette*, London.

still gives Germany the World record for highest average speed (1); it takes third place for steam and fifth, for electric traction.

The number of fast diesel services is still increasing (*FDt* trains); there are more *FD* trains than last year and two all-*Mitropa* stock trains which we refer to at greater length in the following pages.

Since recent political events, the Berlin-Vienna services have been overhauled and all-German ones improved and likely to be further ameliorated in future. A general survey is therefore not out of place.

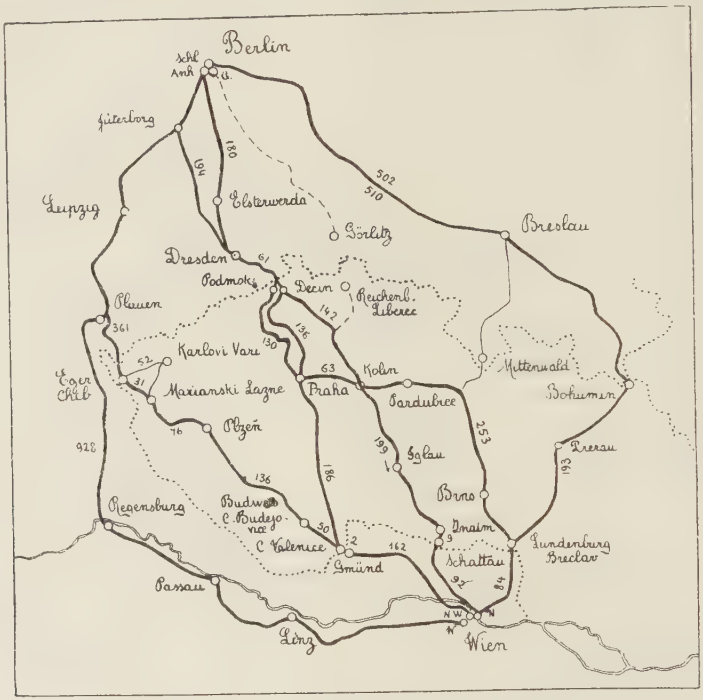



Fig. 4. Railway routes between Berlin and Vienna, showing the actual distances in kilometres.

Conversion of kilometric distances appearing on the map, into miles.

| Km. | Miles. | Km. | Miles. | Km. | Miles. | Km. | Miles. | Km. | Miles. | Km. | Miles. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1.2 | 52 | 32.3 | 92 | 57.2 | 162 | 99.8 | 194 | 120.6 | 510 | 316.9 |
| 9 | 5.6 | 63 | 39.1 | 130 | 80.8 | 180 | 111.9 | 199 | 123.7 | 532 | 330.5 |
| 31 | 19.3 | 76 | 47.2 | 136 | 85.8 | 186 | 113.1 | 253 | 157.2 | | |
| 50 | 31.1 | 84 | 52.2 | 142 | 88.2 | 193 | 119.9 | 361 | 224.3 | 928 | 576.7 |

(1) This applies to the Hanover-Hamm run. The Berlin Zoo-Hanover run which was faster still and therefore had pride of place, has been decelerated by ten minutes.

BERLIN AND VIENNA THROUGH SERVICES are run by various routes (fig. 4). The shortest and the eastern ones pass

through Czechoslovakia whereas the more westerly is the only all-German one.

The earliest of them lies in the East and was completed in 1849 (1); it was followed in 1851 by the Prague-Brno route (2), but it was only after the Wars of 1866 and 1870 that a further impetus was given to Austro-German through traffic. The several Austrian Companies awoke to its importance and each of them sought to run inter-capital expresses over its own tracks.

The *Kaiser Franz Josef* Vienna-Gmund-Prague railway was completed in 1871 and the *Nordwestbahn*'s Vienna-Znaim-Iglau-Jungbunzlau, in 1872. Beyond this place, the railway proceeded through Reichenberg to Berlin, which opened up the shortest route to date. Next, in 1874, the *Nordwestbahn*'s line was extended and cut out Prague on its way to Tetschen so as to meet, by a shorter route, the new Berlin-Elsterwerda-Dresden line which was building and was finished in 1875. Not only did this provide a shorter route than any of the competing ones, but until recent years it has remained the quickest of them all.

Routes lying more in the West were also operated. The first of them was the outcome of through traffic to and from the Bohemian watering places which could be reached from various capitals by « de luxe » expresses belonging to the *International Sleeping-Car Co.* All that remained to be done, so as to open up a new Berlin and Vienna through route, was to link up the Berlin and the Vienna Karlsbad and Marienbad expresses. A « de luxe » day train, the « Berlin and Vienna Express » was inaugurated in 1904 and ran through Eger (Cheb) and Marienbad with a special section to and from Karlsbad (Karlovy-Vary) (3). Distances by all these routes differed by less than 10 p. c. from each other.

Currents of traffic were altered when a new intermediate independent State appeared. All the Berlin-Dresden-Vienna services were diverted so as to run through Prague. Other routes were abandoned; the direct line via Kolin and Iglau, the international expresses by way of Eger, and the projected Reichenbach-Görlitz railway were all given up. On the other hand, a new night service was provided over the Regensburg-Passau route, which has taken on an enhanced importance since the Anschluss, being the only all-German route. A fast *FD* day express and a *Mitropa* all-sleeping-car express have appeared. Although this is by far the longest route, being some 30 p. c. lon-

(1) The railway reached Frankfort on the Oder from Berlin in 1842 and Silesian Wyslowitz in 1846, whilst the *Kaiser Ferdinand Nordbahn* was opened as far as Leipnik in 1842. Under the clauses of a treaty signed between the two countries in 1844, the Austrian *Nordbahn* was to extend its line to the frontier at Oderberg (Bohumin), the German Railways to Annaberg. These places were reached in 1848 and 1847 respectively and joined two years later upon completion of the bridge over the Oder.

These facts and some of the others are taken from an interesting article of Herr B. Meinke, which appeared in the *Zeitung des Vereins.*

(2) The railway from Prague to Olmutz (Olomuc) was opened in 1845 and a branch from Trübau to Brünn (Brno), in 1849, at the same time as the German line from Berlin through Jüterborg to Dresden. A further southerly extension of the *Saxon State Rys.* as far as Niedergrund, on the Elbe, was to provide a second route between Berlin and Vienna.

(3) This train left Berlin at 8.55 a.m. and arrived in Vienna at 9.30 p.m. A section was uncoupled at Eger and reached Karlsbad at 3.50 p.m., whereas à Karlsbad-Vienna portion was due to leave Karlsbad at 1.20 p.m. and join the « Berlin-Vienna Express » at Marienbad, at 2.56 p.m.

ger than the others, it is to become the quicker one, especially when improvements now in hand or shortly to be undertaken will have been carried out. These comprise the building of a new spur line near Regensburg so as to obviate reversing there, double tracking the Passau-Wels section, easing out gradients and curves between Linz and Vienna and, more important still, building an entirely new diversion to better conditions than the existing Plauen-Hof mountain section.

Table 4 gives comparative distances by the various routes together with the best timings during the 1938 Summer (1).

## CHAPTER II.

### Railcars.

Besides Western Europe, fast railcars run in Czechoslovakia, in Hungary, in Rumania, in Poland, in Lithuania, and on the Jugoslav narrow-gauge lines.

TABLE 4.

BERLIN AND VIENNA TRAIN SERVICES BY DIFFERENT ROUTES.

| From Berlin : | Route via : | To Vienna. | Distance | | Time spent. | |
|---|---|---|---|---|---|---|
| | | | Km. | Miles. | Outwards. | Return. |
| | THROUGH SERVICES. | | | | | |
| Schl. Bhf. | Breslau-Bohumin-Breclav . . | Nord. | 779 | 484.1 | 10.15 (2) | Not on return journey. |
| Do. | Sorau - Breslau - Bohumin-Breclav. | Do. | 787 | 489.0 | 12.40 | 12.15 |
| Anhalt. | Decin-Kolin-Znaim . . . . . | Nord. | 683 | 424.4 | Formerly. | Formerly. |
| Do. | Podmokly-Prague-Kolin-Breclav . | Do. | 774 | 480.9 | 12.58 | Not on return journey |
| | Do. | Ost. | ... | ... | 12.58 | 15.48 |
| Do. | Podmokly-Prague-Gmünd . . | Fr. Josef. | 721 | 448.0 | 12.28 | 12.52 |
| *Do.* | *Eger-Pilsen-Gmünd* . . . . . | *Do.* | 818 | 508 3 | *12.35* | *12.33* |
| Do. | Regensburg-Passau-Linz . . . | West. | 927 | 576.0 | 12.03 | 12.07 |
| | OTHER THAN THROUGH SERVICES. | | | | | |
| Schl. Bhf. | Breslau-Mittelwalde-Wildenschwert. | Nord. | 764 | 474.7 | 13.22 | Change en route. |
| Anhalt. | Röderau-Tetschen-Prague-Böhm-Wieland. | — | 730 | 453.6 | Change en route. | Do. |
| Do. | Regensburg-Landshut-Munich . | — | 1 019 | 633.2 | Do. | Do. |
| Do. | Saalfeld-Munich . . . . . | — | 1 121 | 696.5 | Do. | Do. |

I. Great Britain. — The *L. M. S.* is

(1) The kilometrages (mileages) are taken from the German. Czechoslovakian and Austrian official timetables.

(2) The Berlin and Vienna connection via Breslau is made on the down journey by changing from the fast diesel into a connecting ordinary express. It seems likely that permanent through services may be eventually established this way so as to bring the overall time still further down.

proceeding carefully with its tests so as to accumulate personal experience of railcar possibilities.

The *Great Western* runs fast railcars with a number of intermediate stops but the fastest average speed of the non-stop runs does not reach 59 miles an hour (1).

II. **France.** — Even apart from the 140 railcars on order on January 1st, 1938, 662 units are now in service and account for 20 per cent of total passenger, and 11 per cent of the entire train-mileage.

Under these conditions, it is somewhat surprising to note that there seems to be a decided tendency towards curtailing these services; this has already been started and there is every likelihood of further retrenchment taking place at a future date.

The number of fast railcar services has been brought down from four to two between Paris and Le Havre. The Paris-Brussels set has been withdrawn and a steam-hauled train substituted on a somewhat slower schedule.

The former *P. L. M.*'s streamlined train has taken the place of the Paris-Lyons Bugatti triplet which now runs from Mâcon to Geneva in connection with the Paris rapides.

On the other hand, the former *Nord*'s diesel triplets have taken the place of a Paris-Strasbourg rapide with a single stop en route at Nancy, and so cut one hour off previous timings.

A fourth daily service has been added to those existing between Paris and Lille and accomplishes, incidentally, between Paris and Longueau, the fastest run in France. A triple daily railcar service has been introduced from Angers to Rennes and back.

Fast railcars already run from Dieppe to Nantes in connection with cross-Channel packets. It has been decided to run another service in 8 h. 28 m. from Boulogne to Basle so as to enable Londoners to reach Switzerland the same day. The 739 km. (459.2 miles) of the Continental run are to be covered at 98.5 km. (61 miles) an hour by « Nord » three-unit rakes.

The Paris-Liége railcar services have been extended to Maastricht in the Netherlands.

The encouraging results of the Bordeaux-Clermont Ferrand service have been maintained. It will be remembered that on this hard line, 397 km. (246.7 miles), Renault articulated twin railcars equipped with 300-B.H.P. engines each gain two hours on the previous steam-hauled « rapides » in spite of maximum permissible speeds of 140 km. (87 miles) an hour on the level and 96 km. (about 60 miles) an hour on 1 in 100 gradients. This kind of service, with its numerous gradients and light traffic, is an ideal one for railcars, which can be used to advantage when neither of the other kinds of traction gives satisfaction. Traffic is too light to warrant electrification, and gradients too severe for fast steam locomotive running.

V. **The Netherlands.** — The diesel multiple railcars which the extension of Dutch railway electrification has displaced, have been used elsewhere. The most interesting of the new services connect separately the three important towns (Amsterdam, The Hague and Rotterdam)

(1) As a matter of fact, the best service has been slackened since last Summer season. 20 instead of 18 minutes being now awarded to the Castle Cary-Westbury 19.6-mile run; this has brough the average speed down from 65.3 to 58.8 miles an hour.

Fig. 5. — Cartogram of Dutch railcar operation, showing fastest average speeds. Reference, see fig. 1.

with Groningen in the North, Oldenzaal and Enschede in the Centre, and Maastricht in the South of the country (fig. 5).

As with electric traction, the diesel triplets are worked into multiple-unit trains. Rakes coming from The Hague and Rotterdam join up at Gouda, whereas those that run to Hengelo split into separate sections for Enschede and Oldenzaal.

The diesels running from Amsterdam to Groningen or to Hengelo, as also those from Maastricht to Dordrecht, comprise a minimum of two triplets. At peak hours, they are made up of two, three or even four three-car sets.

Diesel trains run over electrified and non electrified lines. Stops are relatively frequent, no non-stop run, with two exceptions, reaching 18 miles. In spite of this, the average speed of non-stop runs is high; it frequently reaches 56 m.p.h. with a maximum of 105.2 km. (65.3 miles) per hour which, barring an electric run, is the fastest in the country. Of course, the diesel's quick acceleration is one of the factors that renders this possible. An average speed of 60.4 m.p.h. is maintained over a 13-mile stretch, of 50 miles (81 km.) per hour on a 6.7-mile (10.8 km.) start to stop run, and 43.1 miles (69.4 km.) per hour on a 5-mile run. This calls for most efficient working.

One service differs from those we have shown in Table 2 in that it is fast from Maastricht to Eindhoven and semi-fast over the 88 km. (55 miles) to Dordrecht. Between Maastricht and Eindhoven, these trains follow the standard fast diesel timings and take 1 h. 16 m., 6 stops included, over the remaining section.

The Amsterdam-Groningen services around the IJsselmeer (former Zuiderzee) have cut the time down from 3 hours to 2 and a half for the 137 miles (221 km.). The overall speed is thus 56.8 miles (91.5 km.) an hour. In the same way, the total journey time between Amsterdam has been brought down from 3 h. 27 m. to 2 h. 47 m., a reduction of about 20 p. c. in both cases.

VI. **Italy.** — See Chapter I.

VII. **Hungary.** — The *Royal Hungarian State Rys.* now run fast diesel services between Budapest and the principal provincial towns (fig. 6). They cover a route mileage of 574.4 (929 km.) of which 346.8 miles (558 km.) at over 50 miles an hour. On the Budapest-Hatvan-Miskolç line alone, steam streamlined tank locomotives are used at practically the same speeds as the diesels.

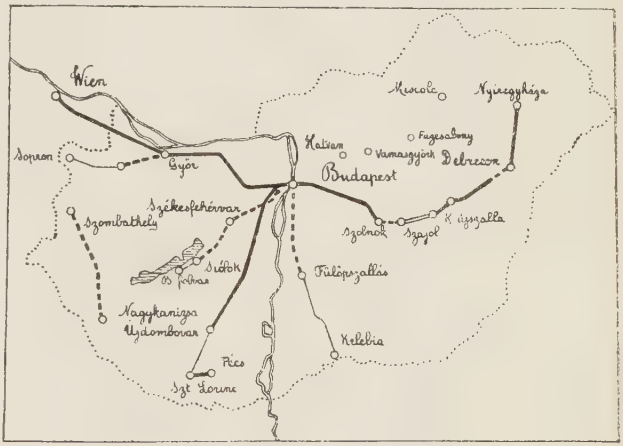



Fig. 6. — Cartogram of fast Hungarian railcar runs showing highest average speeds. Reference, see fig. 1.

TABLE 5.

FAST HUNGARIAN RAILCAR SERVICES.

| RUN. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Number of stops. | Speed. Km./h. | Speed. M.p.h. |
|---|---|---|---|---|---|---|---|
| Budapest Keleti-Vienna Ost ((The « Arpad »). | 260 | 161 6 | 7.00 a. m. | 2.57 | ... | 88.2 | 54.8 |
| Budapest Keleti-Ujdombovar Pécs | 238 | 147.9 | 1.10 p. m. | 3.07 | 5 | 79.9 | 49.6 |
| Budapest Kelenföld-Pusztaszabolcs. | 49 | 30.4 | 1.22 p. m. | 0 35 | ... | 84.0 | 52.2 |
| Pusztaszabolcs-Sarbogard | 30 | 18.6 | 1.58 p. m. | 0.22 | ... | 81.8 | 50 8 |
| Sarbogard-Ujdombovar | 81 | 50.3 | 2.22 p. m. | 0.55 | ... | 88.4 | 54.9 |
| Budapest Keleti-Kishunhalas | 135 | 83.9 | 8 37 a. m. | 1.58 | 6 | 44.8 | 27.8 |
| Budapest Keleti-Debrecen-Nyiregyháza | 270 | 167.8 | 12.40 p. m. | 3 21 | 6 | 80.6 | 50.1 |
| Budapest Keleti-Zahony | 336 | 208 8 | Do. | 4.22 | 9 | 77 0 | 47.8 |
| Budapest-Ujszász | 84 | 52.2 | 12 40 p. m. | 1.01 | ... | 82.6 | 51.3 |
| Szajol-Kisujszallas | 35 | 21.7 | 2 06 p. m. | 0.23 | ... | 91 3 | 56.7 |
| Kisujszallas-Püspökladany | 32 | 19.9 | 2.29 p. m. | 0 22 | ... | 87.3 | 54.2 |
| Püspökladany-Hajduszoboszlo | 24 | 14.9 | 2.52 p. m. | 0.17 | ... | 84 6 | 52.6 |
| Debrecen-Nyiregyháza | 49 | 30 4 | 3.26 p. m. | 0.35 | ... | 84.0 | 52.2 |
| **Steam traction.** | | | | | | | |
| (Hatvan) Vamosgyörk Füzesabony | 38 | 23.6 | up 2.11 p. m. | 0.25 | ... | 90.0 | 55.9 |
| Füzesabony-Miskolc. | 57 | 35.4 | 9.07 p. m. | 0.40 | ... | 85.5 | 53.1 |
| **Electric traction.** | | | | | | | |
| (Budapest) Györ-Hegyeshalom. | 47 | 28.9 | 7.00 p. m. | 0.31 | ... | 91.0 | 55.9 |

X. **Jugoslavia.** — Fast standard-gauge diesels being unavailable, the *State Rys.* have started with narrow-gauge railcars which have been put into traffic on 20th July last on the Belgrade-Adriatic 2' 6" gauge line. This is one of the hardest in the country (1), especially beyond Sarajevo, where gradients of 1 in 63 to 1 in 40 and rack sections with 1 in 17 gradients are to be found.

Curves of 328 to 262 ft. (100 to 80 m.) radius with a minimum of 253 ft. (77 m.) radius occur over half the entire distance from Belgrade to Dubrovnik (685 km. = 425 miles). The first part of the line, as far as Sarajevo, has 134 tunnels, the second part, 34. In spite of speed being restricted to 37 miles (60 km.) per hour only, and even to 26 and 24 miles (42 and 38 km.) on certain sections, the entire journey including 12 stops is accomplished in 16 h. 35 m. at an overall speed of 25.8 miles (41.5 km.) an hour.

One of the most notable features of the services is that the diesel railcars, having no rack wheels, negociate the rack sections by simple adhesion. The speed is 12.4 miles (20 km.) an hour; the summit is reached at 3 103 ft. above sea level. Faster services are under consideration but the line would have to be consider-

(1) See *Bulletin of the Railway Congress*, March, 1936, p. 286 (554).
See also *The Railway Gazette*, 5th August, 1938, from which several items quoted here have been reproduced.

ably improved before anything of the sort could be attempted.

XII. **Rumania** (1). — The fastest services in the country are operated by diesel railcars and radiate from Bucharest along the easily graded Cernavoda line and over the mountainous Brasov one, which negotiates the Transylvanian Alps between Campina (alt. 1 404 ft. = 428 m.) and Brasov (alt. 1 987 ft. = 600 m.), the divide being crossed at 3 458 ft. (1 054 m.) above sea level. Continuous gradients of 1 in 50 occur on the eastern slopes and 1 in 40, on the western (fig. 7).

The latest two close-coupled non articulated units are built by *Ganz*, of Budapest, and the *Malaxa Works*, of Bucharest, and are powered with four 300-B.H.P. engines. Each set seats 68 passengers in a long open saloon. The maximum speed is to be 68 miles an hour.

The usual information concerning these services is given in Table 6. The Brasov diesels serve the well known Sinaia watering place. The eastern line diesels cross the Danube by the Cernavoda bridge and thereafter stop at all stations in the Dobroudja territory ceded to Ru-

TABLE 6.

RUMANIAN HIGH-SPEED RAILCAR SERVICES.

**Heavy** type refers to non-stop runs.

| RUN. | Distance | | Time of departure. | Time spent. | Number of stops. | Speed | |
|---|---|---|---|---|---|---|---|
| | Km. | Miles. | | | | Km.h. | M. p. h. |
| Bucharest North-Brasov . . . | 170 | 105.6 | 7.05 a.m. | 2.50 | 8 | 60.0 | 37.3 |
| Bucharest N.-Ploesti V. . | 63 | 39.1 | Do. | 0.44 | ... | 85.9 | 53.4 |
| Ploesti-Campina . . . . . | 32 | 19.9 | up 11.13 p.m. | 0.22 | ... | 87.3 | 54.2 |
| Comarnic-Sinaia . . . . . | 13 | 8.1 | up 10.39 p.m. | 0.17 | ... | 46.0 | 28.6 |
| Bucharest N.-Bazargic . . . | 311 | 19.3 | 9.30 a.m. | 4.45 | 8 | 65.4 | 40.6 |
| Pantelimon-Ciulnita . . . | 93 | 57.8 | 9.49 a.m. | 0.57 | ... | 97.9 | 60.8 |
| Ciulnita-Cernavoda Pod. . . | 57 | 35.4 | 10.47 a.m. | 0.38 | ... | 90.0 | 55.9 |
| Bucharest N.-Buzau-Galati . . | 260 | 16.2 | 9.10 a.m. | 2.58 | 2 | 87.7 | 54.5 |
| Bucharest N.-Buzau. . . . | 127 | 78.9 | Do. | 1.26 | ... | 89.3 | 55.5 |
| Buzau-Braila . . . . . | 100 | 62.1 | 10.38 a.m. | 1.05 | ... | 92.3 | 57.4 |
| Braila-Galati . . . . . | 32 | 19.9 | 11.44 a.m. | 0.24 | ... | 80.0 | 49.7 |

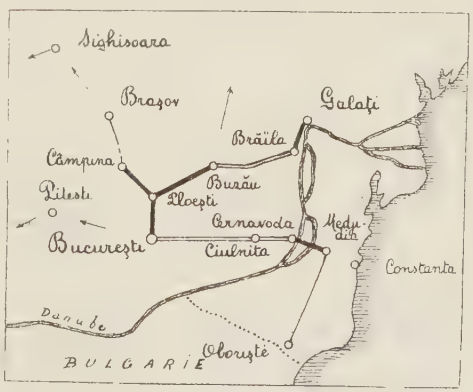



Fig. 7. — Cartogram of fast Rumanian railcar runs showing highest average speeds. Reference, see fig. 1.

(1) As already happened some time back, the name of a number of Rumanian places has been changed. Here is a list of the noteworthy ones :

Decebal has become Curtici;
Gl. M. Jonescu, is now Neptun;
Grigore Ghica Voda, Oaseni;
Igh. Duca is Fabeno;
N. Filipescu, Faurei;
N. Titulescu, Halmein;
Vasile Luppu, Tg. Ungheni.

The name of Elisabethstadt was altered to Ebesfalva, which was changed again to Ibasfalau then in turn, to Dumbroveni. It now appears, this is to be altered again.

mania after the Balkan Wars. Between Bucharest and Ciulnita these diesels gain 6 minutes on the steam-hauled « rapides », the average speed being 54.5 miles (87.7 km.) an hour.

north-eastern frontier and to Katowice and to Krakow in the South, whence other diesels carry on to various frontier mountain resorts (fig. 8). The Katowice region seems to be a particularly likely

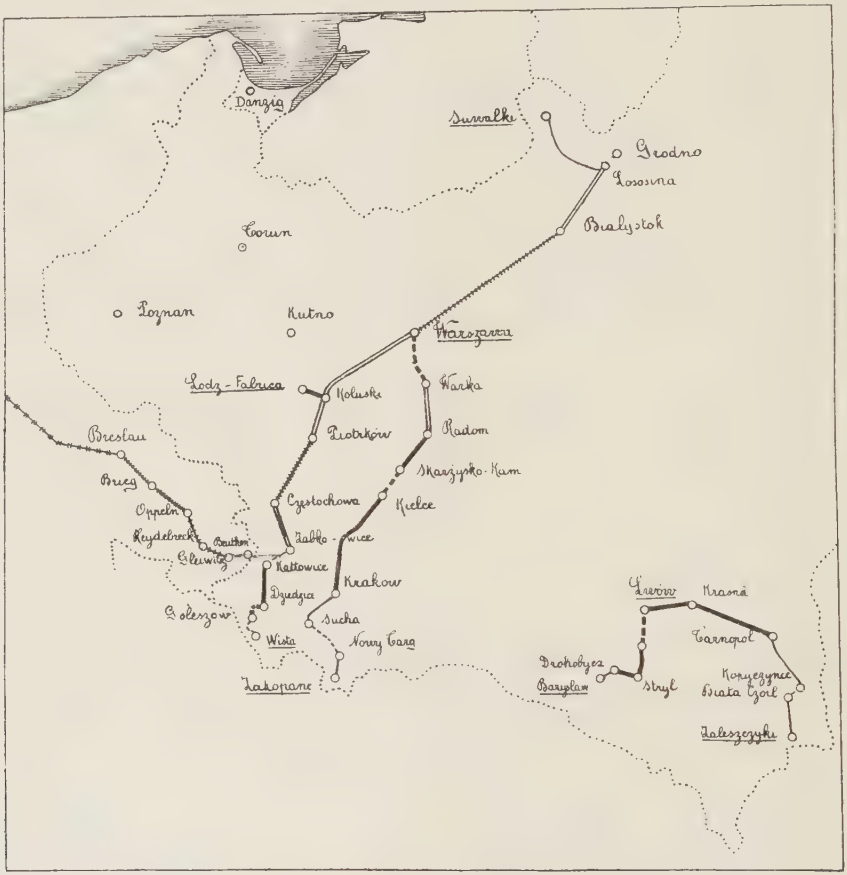



Fig. 8. — Cartogram of fast Polish railcar runs showing highest average speeds. Reference, see fig. 1.

The Bucharest-Buzau diesel run is the longest non-stop run in the country.

XIV. **Poland.** — Fast diesel services radiate from Warsaw to Suwalki by the goal for diesels, as the Berlin-Beuthen railcars run to within a dozen miles of it.

Another set of somewhat slower railcars radiate from Lwow. The usual characteristics are set out in Table 7.

Table 7.

POLISH HIGH-SPEED RAILCAR SERVICES (Mt. E trains).
Non-stop runs are shown in **heavy** type.

| Run. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Number of stops | Speed. Km./h. | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|
| **Railcars.** | | | | | | | | |
| Warsaw Wil.-Suwalki. . . . | 356 | 221.2 | 7.33 p. m. | 4.22 | 3 | 81.6 | 50.7 | ... |
| Warsaw Wil.-Bialystok . . | 179 | 111.2 | Do. | 1 46 | ... | 100.2 | 62.3 | ... |
| Bialystok-Lososina . . . . | 78 | 48.5 | 9.21 p. m. | 0.50 | ... | 93.6 | 58.2 | ... |
| Warsaw Gl.-Lodz Fabrica . . | 130 | 80.8 | 10.40 a. m. | 1 28 | ... | 88.6 | 55.1 | 3 daily. |
| Warsaw Gl.-Katowice. . . . | 318 | 197.6 | 7.00 p. m. | 3.42 | 10 | 86.0 | 53.4 | ... |
| Warsaw Gl.-Koluszki . . . | 105 | 65.2 | 7.00 p. m. | 1.09 | ... | 91.3 | 56.7 | ... |
| Piotrkow-Rademsko. . . . | 45 | 28.0 | 8.36 p. m. | 0.26 | ... | 100.0 | 62.1 | ... |
| Rademsko-Czestochowa. . . | 41 | 25.5 | up 7.55 a. m. | 0.24 | ... | 102.5 | 63.7 | ... |
| Czestochowa-Zawiercie. . . | 44 | 27.3 | 9.29 p. m. | 0.28 | ... | 94.3 | 58.6 | ... |
| Zawiercie-Zabkowice . . . | 19 | 11.8 | 9 57 p. m. | 0.12 | ... | 95.0 | 59.0 | ... |
| (Warsaw) Katowice-Wista . . | 93 | 57.8 | 7.25 a. m. | 1.38 | 6 | 56.9 | 35.4 | ... |
| Warsaw Gl.-Krakow . . . . | 320 | 198 8 | 8 00 a. m. | 3.59 | 7 | 80.0 | 49.7 | ... |
| Warka-Radom. . . . . | 47 | 29.2 | 8.44 a. m. | 0.31 | ... | 91.0 | 56.5 | ... |
| (Warsaw) Krakow-Zakopane . | 144 | 89.5 | 4.00 p. m. | 2.43 | 3 | 52.4 | 32.6 | 3 daily. |
| Lwow-Zaleszczyki . . . . . | 200 | 124.3 | 6.20 p. m. | 4.30 | 9 | 44.5 | 27.7 | 2 daily. |
| Lwow-Boryslaw . . . . . | 113 | 70.2 | 11.30 p. m. | 1.32 | 3 | 73.4 | 45.6 | 2 daily. |
| **Steam traction.** | | | | | | | | |
| Warsaw Gl.-Bialystok. . . . | 183 | 113.7 | up 11.02 a. m. | 2.11 | ... | 83.7 | 52.0 | ... |
| Warsaw Gl.-Zbaszyn . . . . | 379 | 235.5 | 1.23 p. m. | 4.41 | 2 | 81.2 | 50.5 | The « Nord Express ». |
| Warsaw Gl.-Kutno . . . . | 126 | 78.3 | 1.23 p. m. | 1.32 | ... | 82.2 | 51.1 | Do. |
| Kutno-Poznan. . . . . | 178 | 110.6 | 3.01 p. m. | 2.14 | ... | 79.7 | 49.5 | Do. |
| Poznan-Zbaszyn . . . . . | 75 | 46.6 | 5.16 p. m. | 0.48 | ... | 93.8 | 58.3 | Do. |

XVI. **Denmark.** — The opening, on May 15th, 1938, of the Oddesund Bridge across the Western Limfjord has enabled rail communications from Struer, in the South, to Thisted, further North, to be speeded up, as the break of journey due to the rail ferry was the cause of 30 minutes loss of time. Fast diesels will save another three quarters of an hour over this stretch alone. A further saving of from 10 to 28 minutes will occur on the Aarhus-Langaa Jutland main North and South line as soon as the second track will have been laid. Besides this, owing to the completion of the bridge between Aalborg and Norre Sundby, the « Kronjyden Lyntog » continues from Aalborg to Frederikshavn.

The fastest railcar runs occur in the Islands of Zealand and Funen. The quickest of all is accomplished by a relief « lyntog » which only runs on Saturdays and Sundays, during the Summer season. The following are all made at over 100 km. (62 miles) an hour :

| RUN. | Distance, miles. | Time of departure. | Time spent. | Speed, m.p.h. | |
|---|---|---|---|---|---|
| Roskilde-Skagelse (partial section in Zealand). . . . . | 38.3 | 5.42 p. m. | 35 | 65.7 | Relief lyntog. |
| Do. | Do. | 6.12 1/2 p.m | 35 1/2 | 64.8 | « The Midtjyden ». |
| Copenhagen-Korsor (trans-Zealand). | 68.4 | 12.30 p. m. | 65 | 63.1 | « The Englaenderen ». |
| Fredericia-Odensee (Funen) . . . . . | 37.5 | up 7.20 p. m. | 36 | 62.5 | Do. |

XVIII. **Sweden.** — A private Company, the *Varberg-Boràs-Herrlunga Ry.*, has introduced the first fast diesel railcar services into Sweden. Under the name of « Flygande Varbergaren » (Flying Varberger), twin-unit railcars built by the *Linke-Hoffmann Works* and seating 75 passengers are now used. The 90-km. (56 miles) per hour speed limit fixed here, as everywhere in Sweden, could be raised to 100 km. (62 miles) as this speed was reached during the tests.

The advisibility of raising the speed limit to 120 km. (75 miles) an hour is under consideration, but could not be effected without overhauling the permanent way.

XX. **Germany.** — The comprehensive programme of railcar services we previously outlined (1) is being carried out systematically. At the time, besides the Stuttgart-Munich-Berchtesgaden electric sets, 8 of the 20 diesel railcar services were in operation. Save for an extension from Karlsruhe to Basle, four more are now running. The only ones that have not so far materialised are the following :

Berlin to North-Eastern Germany (Stettin and Königsberg) ;
Berlin to Stuttgart direct.

And several cross-country services :

Dresden to Nuremberg ;
Cologne to Stuttgart ;
Karlsruhe-Basle Extension ;
Besides the three Leipzig lines (to Hamburg, to Bremen and to Cologne).

We have considered the Hamburg and Karlsruhe service as being in operation because it is listed in the official *Mitropa* guide of May, 1938, but with the proviso that it is to run from a later date only. Whether or not this will occur in the course of the Summer is an open question. Excluding this service which may be brought into operation any day, the services which are not yet in operation are to extend over 2 312 route miles (3 721 km.), of which 1 537 miles (2 570 km.) have still to be overhauled for ultra high-speed.

Last year, the « Fliegende Kölner » took 1 h. 55 m. on the up journey between Berlin Zoo and Hanover, which was the fastest run in the World (2). In spite of having had 10 minutes added to this timing, the « Fliegende Kölner » is still the fastest, the Hamm to Hanover run being unchanged at a speed of 82.2 miles (132.3 km.) an hour.

There are now three couples of daily

(1) See *Bulletin of the Railway Congress*, August 1937, pages 1 732 and 1 733 (762 and 763).

(2) The speed of 132.6 km. (82.4 miles) per hour has been brought down this year, to 128.1 km. (79.5 miles).

railcar services between Berlin and Hamburg, most of which have been slowed down. Instead of 137 minutes as last year, the fastest of them now takes 140, which is only 9 minutes faster than the best steam train.

Many other runs have similarly been decelerated; experience only will show what the best economic timings should be. 1 427 miles (2 296 km.) are covered by fast railcars at a speed of over 62 miles (100 km.) an hour; 417 miles (672 km.), at 68 to 75 m.p.h.; 680 miles (1 095 km.) at 75 to 80 m.p.h.; and 110 miles (177 km.) at over 80 m.p.h. All these figures include the Hamburg-Karlsruhe service for reasons explained above.

Table 8 shows interesting railcar runs with number of stops and overall speeds and all intermediate ones accomplished at over 62 miles (100 km.) an hour.

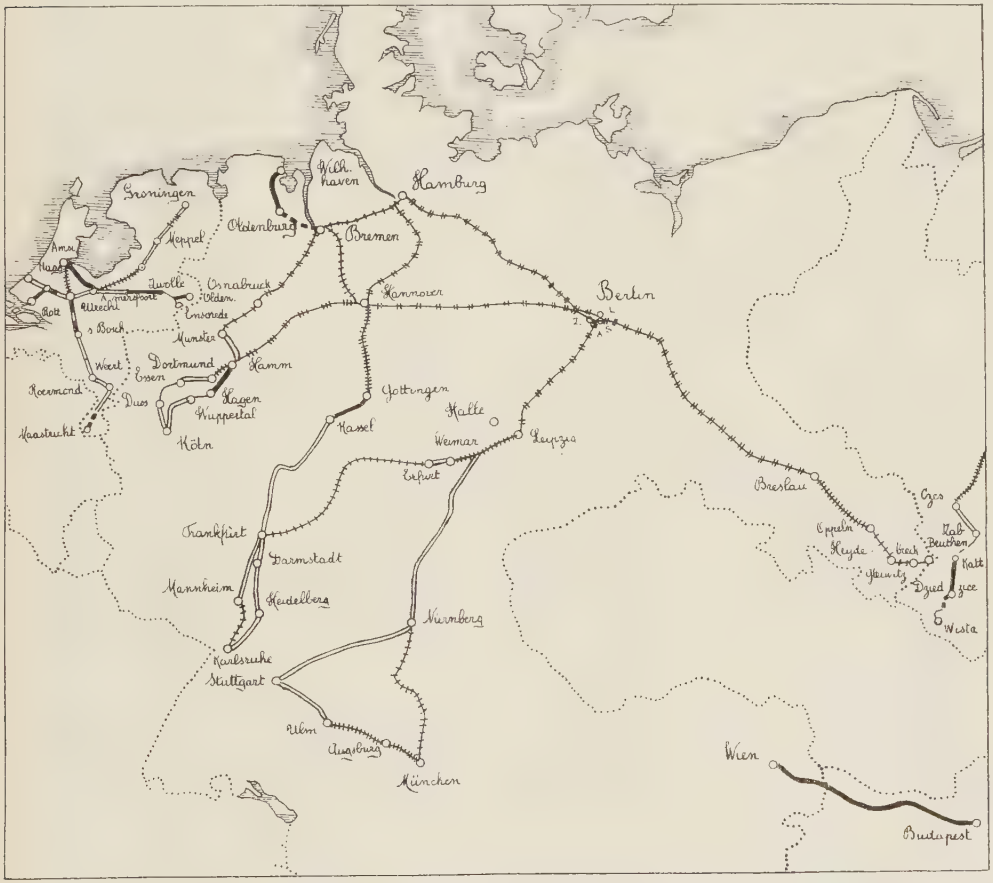



Fig. 9. — Cartogram of high-speed German railcar runs (*FDt* trains) showing highest average speeds.
Reference, see fig. 1.

TABLE 8.

GERMAN HIGH-SPEED DIESEL SERVICES (*FDt* TRAINS).

Non-stop runs in **heavy** type.

| RUN. | Distance. | | Time of departure. | Time spent. | Number of stops. | Speed. | | — |
|---|---|---|---|---|---|---|---|---|
| | Km. | Miles. | | | | Km./h. | M.p.h. | |
| Berlin Lehrter Bhf.-Hamburg (Altona). | 286.8 | 178 1 | **up 10.50 a. m.** | **2.20** | ... | **112.9** | **76.4** | 3 dai |
| Berlin (Schl.) Zoo-Bremen . . . | 376.4 | 233.6 | up 7.15 a. m. | 3 21 | 1 | 112.4 | 69.8 | ... |
| Hanover-Bremen . . . . . | 122.3 | 76.0 | **up 7.15 a. m.** | **1.03** | ... | **116.5** | **72.2** | ... |
| Berlin (Schl.) Zoo-Duisburg Cologne. | 576.0 | 365 4 | up 7.00 a. m. | 5.16 | 6 | 109.4 | 68.0 | ... |
| Berlin Zoo-Hanover. . . . . | 254.1 | 157 8 | **up 8.20 a. m.** | **1.59** | ... | **128.1** | **79 6** | ... |
| Hanover-Hamm . . . . . | 176.4 | 109.6 | **9.19 p. m.** | **1.20** | ... | **132.3** | **82.2** | ... |
| Hamm-Dortmund. . . . . | 31.3 | 19 4 | **10.40 p. m.** | **0 17** | ... | **110.5** | **68.7** | ... |
| Duisburg-Dusseldorf . . . . | 23.6 | 14.7 | **11.37 p. m.** | **0.14** | ... | **101.1** | **62.8** | ... |
| (Berlin) Hamm-Wuppertal-Cologne. | 120.2 | 74.6 | 10 45 p. m. | 1.19 | 2 | 91.3 | 56.7 | ... |
| Berlin Anhalt-Frankfort-Karlsruhe. | 692.4 | 430.0 | **6.40 p. m.** | 6.32 | 6 | 105.9 | 65.8 | ... |
| Berlin Anhalt-Leipzig . . . . | 164.3 | 101.9 | **6.40 p. m.** | **1.17** | ... | **128.0** | **79.5** | 2 dai |
| Weissenfels-Weimar. . . . . | 155.3 | 96.9 | **8.26 p. m.** | **0.32** | ... | **103.7** | **64 4** | ... |
| Erfurt-Frankfort. . . . . | 268.6 | 166 9 | **9.14 p m.** | **2.26** | ... | **110.4** | **68.6** | ... |
| Mannheim-Karlsruhe . . . . | 60.7 | 37.7 | **12.39 a. m.** | **0.33** | ... | **110.4** | **68 6** | ... |
| Berlin Anhalt-Nuremberg-Munich | 685 3 | 42.6 | 6.40 a m. | 6 44 | 2 | 101.8 | 63.3 | ... |
| Nuremberg-Ingolstadt-Munich . | 198.6 | 123.4 | **up 6.40 a. m.** | **1.48** | ... | **110.3** | **68.4** | ... |
| (Berlin) Nuremberg-Stuttgart . | 190.4 | 118.3 | **9.50 p. m.** | **2.03** | ... | **92.1** | **57.7** | ... |
| Berlin (Charl.) Schl.-Breslau-Beuthen. | 508.7 | 310.7 | 8.10 p. m. | 4.28 | 4 | 113 9 | 70.8 | ... |
| Berlin Schl.-Breslau . . . . | 329.5 | 204.7 | **Do.** | **2.41** | ... | **122.8** | **76.3** | ... |
| Breslau-Oppeln . . . . . | 81.7 | 50.8 | **up 6.18 a. m.** | **0.40** | ... | **122.6** | **76.2** | ... |
| Oppeln-Heydebreck . . . . . | 41.5 | 25.8 | **11 39 p. m.** | **0.21** | ... | **118 6** | **73.7** | ... |
| Heydebreck-Gleiwitz . . . . | 37.1 | 23.1 | **up 5.36 a. m.** | **0.19** | ... | **117.2** | **72.8** | ... |
| (Altona) Hamburg Hbf. Hamm-Duisburg-Cologne. | 480 5 | 29.8 | 7 51 p. m. | 4.32 | 8 | 106.0 | 65.9 | ... |
| Hamburg Hbf.-Bremen . . . | 115.5 | 71.5 | **Do** | **0.58** | ... | **119.5** | **74.2** | ... |
| Bremen-Osnabrück . . . . . | 122.1 | 75.9 | **up 9.32 a. m.** | **1.01** | ... | **120.0** | **74.6** | ... |
| Osnabrück-Münster . . . . . | 50.1 | 31.1 | **9.54 p. m.** | **0 26** | ... | **115.4** | **71.5** | ... |
| Münster-Hamm W. . . . . | 35.3 | 53.3 | **9.04 a. m.** | **0.21** | ... | **111.3** | | ... |
| Hamm W.-Dortmund . . . . | 31 3 | 19.4 | **10.45 p. m.** | **0.17** | ... | **110 5** | **68.5** | ... |
| Dusseldorf-Cologne . . . . . | 40.1 | 24.9 | **11.59 p. m.** | **0.24** | ... | **100.2** | **62.3** | ... |
| (Altona) Hamburg-Frankfort-Darmstadt-Heid.-Karlsruhe . | 699.1 | 434.4 | 6.00 p. m. | 7.20 | 7 | 95.3 | 59.2 | ... |
| Hamburg-Hanover . . . . . | 181.6 | 112.5 | **Do.** | **1.30** | ... | **120.6** | **74 9** | ... |
| Hanover-Göttingen . . . . . | 108.2 | 67.1 | **up 11.08 a. m.** | **1.02** | ... | **107.7** | **66.8** | ... |

TABLE 9.

FASTEST AND LONGEST EUROPEAN NON-STOP RAILCAR RUNS.

| Serial number. | Country. | Company. | Run. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Speed. Km./h. | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Fastest run.** | | | | | | | |
| 1 | Germany. | Reichsbahn. | Hanover-Hamm (Cologne) . . | 176 4 | 109.6 | 9.19 p.m. | 1.20 | 132 3 | 82.2 | ... |
| ... | *U. S. A.* | *Union Pacific.* | *(Grand Island-Columbus)* . . | *100* | *62.1* | . . | *0.46* | *131.0* | *81.4* | « *The City of Denver* ». |
| 2 | France. | National Rys. Co. | Paris Nord-Longueau . . . . | 126 | 78.2 | 10 25 a.m. | 1.02 | 121.9 | 75.7 | Northern region. |
| 3 | Netherlands. | Netherlands Rys. | Amersfoort-Zwolle . . . . . | 67 | 41.6 | 6.55 a.m | 0 38 | 105.5 | 65.3 | ... |
| 4 | Denmark. | State. | Odensee-Fredericia . . . . . | 63 | 39.1 | up 7.20 p.m. | 0 36 | 105.0 | 65.2 | « The Englaenderen ». |
| 4 | Italy. | Do. | Turin P. S.-Milan Cent. . . . | 147 | 91 3 | 6.38 a.m. | 1.24 | 105.0 | 65.2 | ... |
| 5 | Poland. | Do. | (Warsaw) Radomsko-Plotrkow | 45 | 28.0 | up 8.19 a.m. | 0.26 | 103.8 | 64.5 | From Krakow. |
| 6 | Czechoslovakia. | Do. | (Prague) Brno-Bratislava . . | 142 | 88.2 | up 6.00 a.m. | 1 26 | 99.1 | 61.6 | « The Blue Arrow ». |
| 7 | Rumania. | Do. | (Buc. N)-Pantelimon-Ciulnita. | 93 | 57.8 | 9 49 a.m. | 0 57 | 97.9 | 60.8 | ... |
| 8 | Great Britain. | Great Western Ry. | Castle Cary-Westbury . . . | 32 | 19.6 | 11.06 a.m. | 0.20 | 94.6 | 58.8 | ... |
| 9 | Lithuania. | State. | Siauliai-Telsiai . . . . . | 70 | 43.5 | 8.45 a.m, | 0.45 | 93.3 | 58.0 | ... |
| 10 | Hungary. | Do. | Szajol-Kisujszallas . . . . . | 35 | 21.7 | 2 06 p.m. | 0.23 | 91.3 | 56.7 | To Nyiregyhaza. |
| | | | **Longest run.** | | | | | | | |
| 1 | France. | National Rys. Co. | Paris Est-Nancy. . . . . | 353 | 219.1 | up 9.30 a.m. | 3.00 | 117.7 | 73.0 | Eastern region. |
| 2 | Germany. | Reichsbahn. | Berlin Schl.-Breslau . . . . | 329.5 | 204.7 | 8.10 p.m. | 2.41 | 122.8 | 76.3 | ... |
| 3 | Hungary. | State. | Budapest-Vienna Ost . . . . | 260(1) | 161.6(1) | 7.00 a.m. | 2.57 | 88.2 | 54.8 | « Arpad ». |
| 4 | Czechoslovakia. | Do. | Prague Wils.-Brno. . . . . | 255 | 158.4 | 6.34 a.m. | 2.47 | 91.6 | 56.9 | ... |
| 5 | Denmark. | Do. | Nyborg-Aarhus . . . . . | 198 | 123.1 | 10.24 a.m. | 2.06 | 94.3 | 58.6 | « Kronjyden ». |
| 6 | Poland. | Do. | Warsaw Wl.-Bialystok . . . | 177 | 110.0 | 7.33 p.m. | 1.46 | 100.2 | 62.3 | ... |
| 7 | Italy. | Do. | Turin P. S.-Milan Cent. . . . | 147 | 91 3 | 6.38 a.m. | 1.24 | 105.0 | 65.2 | ... |
| 8 | Rumania. | Do. | Bucharest N.-Buza . . . . . | 128 | 79.5 | 9.10 a. . | 1 26 | 89.3 | 55.5 | ... |
| 9 | Lithuania. | Do. | Telsiai-Kretinga . . . . . | 72 | 44.7 | 9.31 a.m. | 0.52 | 83.1 | 51.6 | ... |
| 10 | Netherlands. | Netherlands Rys. | Amsterdam-Zwolle . . . . . | 67 | 41.6 | 6.55 a.m. | 0.38 | 105.5 | 65.3 | ... |

(1) 72 km. (44.7 miles) are in Germany, the balance (188 km. = 116.8 miles) in Hungary. This distance does not take into account the 12 virtual km. (7.5 miles) due to the bridge over the Danube, which are added for tariff purposes.

XXI. Europe. As usual, we have included in Table 9, the principal characteristics concerning the fastest and longest non-stop runs in each European country. We have added for comparison purposes, the fastest American run.

Railcar average speeds of more than 75 m.p.h. are to be found in Germany, in the U. S. A. and in France. Four other countries — the Netherlands, Denmark, Italy and Poland — have runs at over 62 m.p.h.

Non-stop diesel runs of over 200 miles occur in France and in Germany; over 150 miles in Hungary and Czechoslovakia (3rd and 4th places); over 100 miles, in Denmark and Poland (5th and 6th). Italy does not quite reach this standard.

## CHAPTER III.

### Electric traction.

In the course of the year, the working of Dutch, Italian and Swiss railways has been improved and the electrification of British, Dutch, Italian and Swedish lines extended. In the Netherlands, the entire operation of the electric lines has been re-planned; the number of Swiss fast light electric trains has been increased; the speed of the Italian ones has again advanced. To a lesser degree, there has been progress in France and in Sweden. Taken as a whole, European electric traction has scored during the year under review.

I. Great Britain. — The *Southern Ry. Co.* has consistently extended electrification which now comprises 615 route- and 1 567 track-miles, including the latest Mid-Sussex and Sussex Coast routes. Each step forward entails timetable overhauling as on the Waterloo-Portsmouth line, which has now taken on the characteristics of an outer suburban railway but, so far, no really fast running is accomplished by any of the electric trains. Although for years past, the 50 miles from London to Brighton have been covered in the round hour, it is with ever renewed astonishment that we note that no improvement is ever brought to this leisurely timing.

Elsewhere, however, considerable praise is due to the remarkable progress achieved in the already high standard of working of the London underground system. The railway's capacity has been further increased by a better planning of the new seven-car trains (1) and increased accelerating and braking power so as to reduce headway and thereby increase the capacity of the line.

Every motor coach has a 168-H.P. motor on each bogie, the seven-car train having 10, totalling 1 680 H.P. (2). The increased acceleration is thus at the rate of 1.50 miles per second in tunnels. The trains are thus able to reach a speed of 30 m.p.h. in 20 seconds and this in turn allows closer spacing so that 48 can be run instead of 40 an hour without having to increase their running speed.

Owing to greater passenger-carrying capacity, steps had to be taken to prevent any loss of time at the stations (3). When

(1) The motor coaches have seating accommodation for 42 passengers, the other coaches, 40. Their body length is 52' 3 3/4" and 51' 2 3/4" respectively.

(2) The previous type only had 1 440 H.P.

(3) The equipment having been placed under the flooring, there is a 20 p. c. increase in the passenger carrying surface. To facilitate access and egress, the doorways have been widened from 10' 3" to 12' 2".

This information has been communicated by Mr. H. R. Broadbent, of the *L. P. T. B.*

40 trains are running per hour, the aggregate loss accruing from 2 1/4 seconds delay in each station reduces by one the total number of trains per hour; were 48 trains running every hour, one train would have to be knocked off if 1 1/2 seconds are lost in each station.

II. **France.** — Several of the Paris-Le Mans rapides have been accelerated to run in 2 h. 5 m. instead of 2 h. 15 m. This works out at 62.9 m.p.h. average speed.

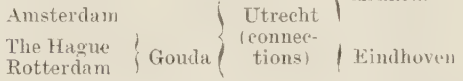
Electrification of the South Western main line is drawing to a close; it is expected that the 214.4 miles (345 km.) from Tours to Bordeaux will be completed by the end of the year, thus providing an unbroken run by electric traction, of 507 miles (816 km.) from Paris to Hendaye. The longest booked non-stop run is accomplished either way by the « Barcelone Express »; as a matter of fact, there now are « safety service stops » of 5 seconds each at Vierzon and Châteauroux, the overall timings having been extended by five minutes in consequence.

A new Paris-Toulouse « rapide », non-stop as far as Limoges but with service stops at Vierzon and Châteauroux, cuts 2 hours off previous timings on the down journey and 49 minutes on the up. It takes 4 h. 41 m. outwards, 4 h. 38 m. back.

V. **The Netherlands.** — Electric route-mileage has been increased from 146 to 317 (235 to 510 km.). The Dordrecht-Amsterdam and Alkmaar lines are unchanged; we shall therefore deal with the others only.

All lines centering on Utrecht, with the exception of the Amersfoort one, are now electrified; eastwards and to the south east, to Arnhem and to Eindhoven, westwards to Holland's three large towns, Amsterdam, The Hague and Rotterdam.

So that all these places should have equal facilities, multiple-unit traction has been resorted to, the Hague and Rotterdam trains joining at Gouda and proceeding together to Utrecht where all trains connect. Elsewhere, they often stop for 1 or 2 minutes, this time being needed for transfer to or from the road bus services. Standardised services have therefore been arranged as under :




Three-car rakes start from The Hague and Rotterdam. When traffic warrants it, there are as many as three three-car sets plus two extra cars, the Hague and Rotterdam trains joining at Gouda and running as a single 6-, 8-, or (maximum) 10-car train to Utrecht, where the extra two cars are uncoupled from the front or back of the train or, in the case of ten-car trains, from both front and back. Beyond, they only comprise two three-car sets.

So as to provide through trains between most places, and to obviate always having to change trains between the same places, the trains coming from The Hague-Rotterdam do not all run to Eindhoven, nor those from Amsterdam all to Arnhem, being tangent in Utrecht. At other times, the Hague-Rotterdam trains go to Arnhem and the Amsterdam ones to Eindhoven, these trains crossing at Utrecht.

All the sets are provided with a buffet section for light refreshments, worked by the *International Sleeping-Car Co.*

Many of the partial runs are accomplished at average speeds of 56 and even 62 m.p.h., the maximum reaching 67.5 miles (108.2 km.) an hour. But though

less spectacular, others such as the 4.8-mile (7.8 km.) run from Culemborg to Geldermalsen which is accomplished in 5 minutes at the truly remarkable average speed of 57.9 miles (93.2 km.) an hour, are more remarkable still. It is over these quick short runs that both electric and diesel traction show undisputable advantage over steam.

VI. Italy. — Here also, electrification is proceeding apace. The year 1937 has witnessed the completion of the Salerno-Reggio di Calabria west coast line's electrification (261 miles = 420 km.), thus providing unbroken electric traction from the southernmost point in Italy as far north as Bologna, 682 miles (1 097 km.) away. This is being extended another 137 miles (219 km.) to Milan. Work is proceeding besides on an extension from Bologna to Ancona and on the coast line from Pisa to Rome.

Although the public timetables show steam-drawn trains running non stop in 5 h. 15 m. over these 209 miles (336 km.), several service stops for taking water take place. Several important trains, such as the « Paris-Rome Express » and the Milan and Geneva « rapidi », that formerly ran over this route, have been diverted from Pisa to Florence and thence to Rome, which lengthens the run by 41.6 miles (67 km.). Upon completion of the Rome-Pisa electrification in November, 1938, they will probably resume their former paths at enhanced speed.

Electric locomotives haul all heavy trains. Three-car articulated *Breda* sets are used for light fast trains. They are powered with 6 motors developing 1 200 H.P. and reach a maximum speed of 160 km. (99 miles) an hour. They weigh 117 tons and are 62.80 m. (206') long.

The remarkable run of the Bologna-Florence-Rome-Naples « electrotrain » has again been improved and timings over each section further pared down. The 71.8 miles (115.6 km.) an hour commercial speed it maintains between Rome Term. and Naples gives Italy the lead, as far as electric traction goes, among European countries and if all kinds of traction be taken into account, the fourth place in Europe, immediately after Germany, France and Great Britain. But it is intended to further improve these already fine achievements.

A test run was made on 27th July, 1938, on a 90-minute schedule and the down run was accomplished in 1 h. 24 m., the up one, in 1 h. 36 m., at the remarkable average speed of 161.9 and 131.3 km. (100.6 and 81 miles) an hour. But maintaining them in everyday service is a very different thing from such an exceptional achievement and before this could be done, the track would need a good deal of attention. Nevertheless, it is hoped eventually to run the trains on this ninety-minute schedule.

IX. Switzerland. — Owing to the popularity of the light limited fast trains running between Geneva and Zurich, most important Swiss towns have been inter-connected in the same way.

Actually, this carries out the idea that was started many years ago in Belgium of running fast local set trains between principal towns with this difference that whereas the Belgian « trains-blocs » had steam locomotives, the Swiss « light limited trains » are run by electric traction (fig. 10).

Both electric motor coaches and locomotives are used. The first Geneva-Zurich trains were three-unit motor coach and trailer sets, the newer ones consist-

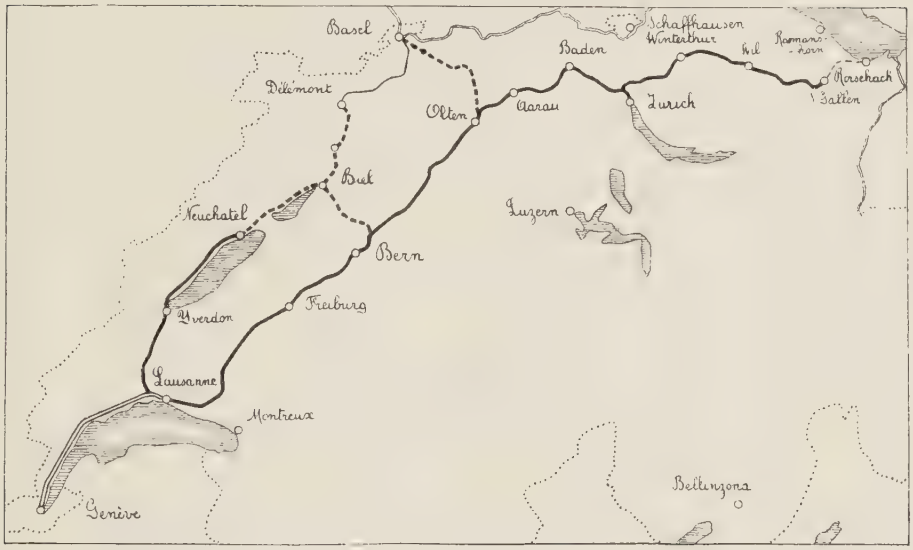



Fig. 10. — Cartogram of Swiss high-speed light trains showing average speeds. On the Basle-Baden section of the Basle-Zurich line, which is not shown, there is a high-speed light train in one direction only.
Reference, see fig. 1.

ing in five-coach rakes hauled by an electric locomotive.

The new three-coach streamlined sets accomplish a daily circuit of 734 km. (457 miles) from :

Rorschach to Zurich and Berne;
Berne to Biel and back;
Berne to Olten, Basle and back;
Berne to Zurich and Rorschach.

Two locomotive-hauled sets accomplish quite as complicated a circuit, one one way, the other in the opposite direction :

Zurich to Berne and Geneva;
Geneva to Lausanne, Biel and Basle;
Basle to Zurich;
Zurich to Berne and Geneva.

This aggregates a daily run of 911 km. (566 miles), taking 10 h. 43 m. running time. Each set comprises one 48-seat 2nd-class car, two 72-seat 3rd-class cars having 8 tip-up seats as well, and a luggage van with buffet compartment. These cars are light and weigh but 27 tonnes each.

There are also two-car units weighing 78 tonnes and seating 126 passengers; their maximum speed is 150 km. (93 miles) an hour.

Owing to the mountainous nature of the greater part of the country, high speeds cannot be expected save along the Lake of Geneva, between Geneva and Lausanne and in the Rhône Valley. We therefore quote, in Table 10, besides other interesting runs, all those made at 50 miles an hour and over.

TABLE 10.

SWISS HIGH-SPEED LIGHT TRAINS.

Non-stop runs shown in **heavy** type, discontinued services in *italics*.

| RUN. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Number of stops. | Speed. Km./h | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|
| **Fast light trains.** | | | | | | | | |
| Lausanne-Biel-Basle | 177 | 110.0 | 2.12 p.m. | 2.26 | 3 | 71.4 | 44.4 | ... |
| Lausanne-Neuchâtel | 74 | 46.0 | **Do.** | 0.53 | ... | 83.8 | 52.1 | ... |
| Geneva-Lausanne-Berne-Zurich | 288 | 179.0 | 6.30 a.m. | 3.20 | 2 | 86.4 | 53.7 | ... |
| Geneva-Lausanne | 60 | 37.3 | **Do.** | 0.37 | ... | 97 3 | 60.5 | ... |
| Lausanne-Berne | 98 | 60.9 | 7.08 a.m. | 1.10 | ... | 84.0 | 52.2 | ... |
| Berne-Zurich Hbf. | 130 | 80.8 | 8.20 a.m. | 1.30 | ... | 86.7 | 53.9 | ... |
| Berne-Biel | 34 | 21.1 | 12.08 p.m. | 0.26 | ... | 78.5 | 48.8 | ... |
| Berne-Olten-Basle | 105 | 65 2 | 3.13 p.m. | 1.17 | 1 | 81.8 | 50.8 | ... |
| Berne-Olten | 66 | 41.0 | **Do.** | 0.46 | ... | 86.1 | 53.5 | ... |
| Berne-Olten-Zurich-Rorschach | 229 | 142.3 | 7.13 p.m. | 3.09 | 5 | 72.7 | 45.2 | ... |
| Zurich-Winterthur | 27 | 16.8 | 9.05 p.m. | 0.19 | ... | 85.3 | 53.0 | ... |
| Winterthur-St. Gallen | 57 | 35.4 | up 8.14 a.m. | 0 39 | ... | 87.7 | 54.5 | ... |
| Zurich-Basle | 89 | 55.3 | 10.18 a.m. | 1.05 | ... | 82.2 | 51.1 | ... |
| **Other trains.** | | | | | | | | |
| Winterthur-Frauenfeld | 16 | 9.9 | 10.38 a.m. | 0.11 | ... | 87.3 | 54.2 | ... |
| *Basle-Aarau-Bellinzona* | 255 | 158.4 | *1.08* a.m. | *3.41* | ... | *69.2* | *43.0* | « Riviera Express » 1937/1938 winter. |
| (Lucerne) Arth Goldau-Bellinzona | 142 | 88.2 | up 7.45 p.m. | 2.04 | ... | 68.7 | 42.7 | ... |

XVIII. Sweden. — Here again, electrification is advancing steadily. The main electrified 630-km. (391 miles) line from Stockholm to Trälleborg is now the second longest in Europe, coming after the Italian Milan-Reggio di Calabria, and preceding the German 394 km. (248 miles) one, from Stuttgart to Munich and Salzburg.

Adding electrified extensions to these lines, Sweden heads the list with 1 145 km. (712 miles) due to the recent electrification of the Trälleborg-Mjölby-Ange railway, thus beating Italy by 48 km. (30 miles).

Average speeds of 50 m.p.h. are frequent in Sweden, but 53 m.p.h. is now the maximum to be found there.

XX. Germany. — The 1938 speeds of the Southern German electrified system are slightly lower than the 1936 ones, and the fast light limited motor- and trailer-car trains no longer proceed beyond Munich to Berchtesgaden.

Now that electrification has reached Nuremberg, all the fast trains from Munich run via Augsburg with the exception of the *FDt* diesel multiple-units which still run via Ingolstadt. The distance by the two routes is identical and over the latter, the average speed of the fastest electric train does not attain 56 m.p.h.

The electrification of the Nuremberg-Leipzig and Halle section (195 miles, Nuremberg to Halle, besides the Leipzig

TABLE 11.

FAST GERMAN ELECTRIC TRAINS.

Non-stop runs in **heavy** type.

| RUN. | Distance. | | Time of departure. | Time spent. | Number of stops. | Speed. | | — |
|---|---|---|---|---|---|---|---|---|
| | Km. | Miles. | | | | Km.-h. | M.p.h. | |
| eipzig) Halle-Köthen (Magdeburg). | 35.9 | 22.3 | 8.32 a. m. | 0.20 | ... | 107.7 | 66.9 | *D* train. |
| Köthen-Calbe East. . . . | 22 7 | 14.1 | 9.07 a. m. | 0.13 | ... | 103.4 | 64.3 | Do. |
| Schönebeck-Magdeburg. . . | 15.1 | 9.4 | 2.00 p. m. | 0.09 | ... | 100.7 | 62.6 | Do. |
| eslau-Königszelt- (Hirschberg). | 48.4 | 30.1 | 9.11 a. m. | 0.27 | . . | 107 6 | 66 8 | ... |
| uttgart-Ulm-Munich . . . | 240 | 149.1 | up 10.10 p. m. | 2.46 | ... | 86.7 | 53.9 | «Orient Express». |
| Stuttgart-Ulm. . . . . | 93 | 57.8 | up 8.52 a. m. | 1.02 | ... | 90 0 | 55 9 | *Dt* train. |
| Ulm-Augsburg. . . . . | 86 0 | 53.4 | up 12.37 p. m. | 0.49 | ... | 105.3 | 65.4 | Do. |
| Augsburg-Munich . . . . | 61.9 | 38.5 | up 12.00 noon | 0.36 | ... | 103.3 | 64.2 | Do. |
| gsburg-Nuremberg . . . . | 137.2 | 85.2 | 12.44 p. m. | 1.20 | ... | 102.9 | 63.9 | *FD* train. |

branch), will link the Southern electric system with the Dessau-Bitterfeld-Magdeburg one, and when the electrification of the Stuttgart-Weil der Stadt line will have been completed, the Reichsbahn will have 1 616 miles of electric lines, which represents roughly, 4.8 p.c. of the entire system.

Fast running occurs on the further extension north of Halle where some of the Magdeburg trains run at 66.9 miles (107.7 km.) per hour, the highest speed to be found on German electrified lines. This comes just ahead of the fastest run on the eastern electrified lines, where a single one of the 27-minute Breslau-Königszelt trains runs as formerly, the two others now taking 32 minutes instead of the previous 27.

XXI. Europe. — Table 12 summarizes comparative characteristics of the best electric runs in each of the European countries. As usual, we have quoted the best American run for reference and shown it in italics, as also certain others which it is useful to quote though not strictly coming under the Table's heading. This applies to the « Sud Express » conditional run. We also quote the best German motorcoach run (Munich to Augsburg) the fastest, shown in usual types, being locomotive-hauled. The *Etat*'s best effort being slower than the fastest on the South-Western region, it is also shown in italics.

In the table of longest non-stop runs, we have attributed italics to the longest of the Swiss ones, as it only takes place during the winter months.

Italy's « electrotrain » heads the list of fast European non-stop runs, though occasionally, when the Les Aubrais stop occurs, the *P. O.* run is quicker. As it is optional, it is quoted but not listed in the regular sequence. Next come France, Germany and, since May 1938, the Netherlands, all of which have runs at over 66 m.p.h.

The longest public time-table non-stop run is to be found in France but is broken into by service stops. Italy therefore heads the list with a run nearly 200 miles in length, and is followed in the winter months by Switzerland, next by

TABLE 12.

OVERALL SPEEDS OF THE FASTEST RUNS AND LONGEST NON-STOP RUNS OF THE DIFFERENT EUROPEAN COUNTRIES.

ELECTRIC TRACTION.

| Serial number. | Country. | Company. | Run. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Speed. Km./h. | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Fastest run.** | | | | | | | |
| ... | *U. S. A.* | *Chicago, N.S. & M.* | *Kenosha-Waukegan* . . . . | *24* | *14.9* | ... | *0.12* | *120.7* | *75.0* | ... |
| ... | *France.* | *National Rys. Co.* | *Les Aubrais-St. Pierre-des-Corps* | *112* | *69 6* | *12.43* p.m. | *0 58* | *115.8* | *72.0* | *The « Sud Express ».* |
| 1 | Italy. | State. | Rome Term.-Naples Merg. . . | 210 | 130 5 | **8.14** p.m. | **1.49** | **115.6** | **71 8** | Electrotrain. |
| 2 | Netherlands. | Netherlands Rys. | Driebergen Ede-Wageningen . | 29 | 18 0 | **7 17** a.m. | **0.16** | **108.2** | **67.5** | ... |
| 3 | Germany. | Reichsbahn. | Halle-Köthen . . . . . | 36 | 22.3 | **8.32** a.m. | **0.20** | **107.7** | **66 9** | *D* train 192. |
| ... | *Do.* | *Do.* | *Munich-Augsburg* . . . . . | *61* | *37.9* | *12.00* noon | *0 36* | *103.2* | *64 1* | *Multiple-unit railcar.* |
| 4 | France. | National Rys. Co. | Paris Orsay-St. Pierre-des-Corps | 235 | 146 0 | **11.30** a.m. | **2.11** | **107.6** | **66.8** | The « Sud Express ». |
| ... | *France.* | *National Rys. Co.* | *Paris Mp.-Le Mans.* . . . . | 211 | 131.1 | **8.00** a.m. | **2.05** | **101 2** | **62.9** | ... |
| 5 | Switzerland. | Federal. | Geneva-Lausanne . . . . . | 60 | 37.3 | **6 30** a.m. | **0.37** | **97 3** | **60.5** | Fast light train. |
| 6 | Hungary. | State. | (Budapest) Györ-Hegyeshalom | 47 | 29.2 | **up 7.00** p.m. | **0 31** | **21.0** | **56.5** | The « Arlberg Express ». |
| 7 | Belgium. | National Rys. Co. | Brussels N.-Antwerp C. . . . | 45 | 28.0 | Many | **0.29** | **86.2** | **53 5** | ... |
| 8 | Great Britain. | Southern Ry. | London Bridge-Brighton . . . | 81 | 50.3 | **5 00** p.m. | **0.57** | **85 8** | **53.3** | ... |
| 9 | Sweden. | State. | (Stockholm) Nässjö-Alvesta . | 87 | 54.1 | **3.27** a.m. | **1.01** | **85.6** | **53.2** | To Malmö. |
| | | | **Longest run.** | | | | | | | |
| ... | *France.* | *National Rys. Co.* | *Paris Orsay-Limoges* . . . . | *404* | *251.0* | *8 15* a.m. | *4.41* | *86.3* | *53.6* | The « Barcelone Expr. ». |
| 1 | Italy. | State. | Florence S. M. N.-Rome Term. | 316 | 196.4 | **5.00** p.m | **3.07** | **101.4** | **63.0** | Electrotrain. |
| ... | *Switzerland.* | *Federal.* | *Basle-Bellinzona.* . . . . . | *255* | *158.4* | *1.08* a.m. | *3.40* | *69.2* | *43.0* | The « Riviera Expr. ». In Winter only. |
| 2 | Germany. | Reichsbahn. | Stuttgart-Ulm-Munich. . . . | 240 | 149.1 | **up 10.10** p.m. | **2.46** | **86.7** | **53.9** | The « Orient Express ». |
| 3 | France. | National Rys. Co. | Paris Orsay-St. Pierre-des-Corps | 235 | 146.0 | **11.30** a.m. | **2.11** | **107.6** | **66.8** | The « Sud Express ». |
| 4 | Sweden. | State. | (Stockholm) Bollnas-Ange . . | 168 | 104 4 | **12 24** a.m. | **2.05** | **80.0** | **49.7** | Northwards. |
| 5 | Switzerland. | Federal. | Arth Goldau-Bellinzona . . . | 142 | 88.2 | **up 7.45** p.m. | **2.04** | **68.7** | **42.7** | ... |
| 6 | Hungary. | State. | Budapest Kelenföld-Györ . . | 130 | 80.8 | **8.28** a.m. | **1.34** | **85 1** | **52.9** | The « Arlberg Express ». |
| 7 | Great Britain. | Southern Ry. | Waterloo-Portsmouth . . . . | 118 | 73.3 | **3.16** p.m | **1.29** | **79.4** | **49.3** | ... |

German and French locomotive-hauled train runs, both very near to 150 miles in length.

## CHAPTER IV.

### Steam traction.

It is satisfactory to note that steam traction has not been left stranded by the improvements brought to the other methods of traction and has forged ahead in spite of the progress of electricity and the railcar. The greatest strides have been accomplished in Great Britain and in Germany but everyday practice in Belgium and in France shows that in neither country is steam likely to be abandoned.

On the other hand, countries such as the Netherlands and Italy, that have definitely taken up other systems, have retained steam for their less important services after having handed the best of them and particularly the fast light ones to diesel or electric trains.

I. Great Britain. — Whereas on the *Great Western Ry.* and *Southern Ry.*, fast trains are practically unchanged since last year, there is much of interest to note in those of the West and East coast Companies without mentioning streamlined locomotives and trains whose main characteristics we give in Table 13.

The first British streamlined train, « The Silver Jubilee » made its maiden trip on 30th September, 1936. « The Coronation », « The Coronation Scot » and « The West Riding Ltd. » all followed in 1937. Only the locomotive of « The East Anglian » is streamlined.

« The Bristolian », which is not streamlined and whose speed, although the train is made up of ordinary stock, is comparable to the others', has been added for comparison purposes.

Thanks to « The Coronation », Edinburgh can now be reached in 6 hours from London, and Glasgow over the metals of the competing West Coast Company in 6 1/2 hours.

The former's average speed between King's Cross and York is 71.9 m.p.h., the highest in the British Isles, the timings of the *Great Western*'s « Cheltenham Flyer » having remained unchanged for several years. In everyday practice, these trains reach a speed of 90 m.p.h., 3 miles more than do the Ghent-Bruges Belgian expresses.

« The Coronation » is a London train inasmuch as it takes Londoners to Scotland and back; « The Silver Jubilee », « The West Riding Ltd. » and « The East Anglian » might be called provincial trains in that they start in the morning from the Provinces, arrive in London at the beginning of the afternoon and leave towards 7 p.m. so as to get back the same evening. Luncheon is taken on board on the up journey and dinner on the way back.

An extra fare is collected on the trains, as on the Pullmans. It varies from 3 to 6 sh. in first, and from 2 to 4 sh. in third. All the above are set trains; three sets and 5 locomotives are available for each of the Scottish trains. The Coronation's corridor tenders carry 8 tons of coal and 5 000 gallons of water; the « Coronation Scot »'s locomotives, 10 tons and 4 000 gallons. The crew is changed at Carlisle.

The *L. and N. E.* streamlined trains are articulated, the others, not. « The Silver Jubilee » comprises two kitchen cars half of which is available for passengers; two cars of each of the others are entirely devoted to cooking and pantry purposes. « The West Riding Ltd. » differs from

TABLE 13.

BRITISH STREAMLINE TRAINS.

| RUN. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Number of stops. | Speed. Km./h. | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|
| **Streamline trains.** | | | | | | | | |
| LONDON AND NORTH EASTERN RY. | | | | | | | | |
| King's Cross-Newcastle . . . | 432 | 268.3 | 5.30 p. m. | 4.00 | 1 | 108.0 | 67.1 | « The Silver Jubilee ». |
| King's Cross-Darlington . . | 374 | 232.3 | Do. | 3 18 | ... | 113.3 | 70.4 | Do. |
| Darlington-Newcastle . . . | 58 | 36.0 | 8.50 p. m. | 0.40 | ... | 87.0 | 54.1 | Do. |
| King's Cross-Edinburgh Waverley. | 632 | 392.7 | 4.00 p. m. | 6.00 | 2 | 105.4 | 65.2 | «The Coronation». |
| King's Cross-York . . . . | 303 | 188.2 | Do. | 2.37 | ... | 115.7 | 71.9 | Do. |
| York-Newcastle . . . . . | 129 | 80.2 | 6.40 p. m. | 1.17 | ... | 100.5 | 62.4 | Do. |
| King's Cross-Newcastle . . | 432 | 268.3 | up6.33 p. m. | 3.57 | ... | 109.3 | 67.9 | Do. |
| Newcastle-Edinburgh Waverley. | 200 | 124.4 | 8.00 p. m. | 2.00 | ... | 100.1 | 62.2 | Do. |
| King's Cross-Leeds-Bradford Exchange. | 314 | 195 3 | 7.10 p. m. | 3 05 | 1 | 101.9 | 63.3 | « The West Riding Ltd. ». |
| King's Cross-Leeds Central . | 299 | 185.7 | Do. | 2.43 | ... | 110.1 | 68.4 | Do. |
| Leeds Central-Bradford Exchange. | 25 | 15.5 | 9.57 p. m. | 0.18 | ... | 82.0 | 51.0 | Do. |
| LONDON MIDLAND AND SCOTTISH RY. | | | | | | | | |
| Euston-Glasgow Central. . . | 646 | 401.4 | 1.30 p. m. | 6 30 | 1 | 99.4 | 61.7 | « The Coronation Scot ». |
| Euston-Carlisle . . . . . | 167 | 290.1 | Do. | 4.43 | ... | 102.0 | 63.4 | Do. |
| Carlisle-Glasgow Central. . | 165 | 102.3 | 6.15 p. m. | 1.45 | ... | 94.3 | 58.5 | Do. |
| **Other trains.** | | | | | | | | |
| LONDON AND NORTH EASTERN RY. | | | | | | | | |
| London Liverpool Street-Norwich Thorpe. | 185 | 115.0 | 6.40 p. m. | 2.10 | ... | 85.4 | 53.1 | « The East Anglian ». |
| Liverpool Street-Ipswich . . | 111 | 68.7 | Do. | 1.20 | ... | 82.5 | 51.5 | Do. |
| Ipswich-Norwich Thorpe . . | 76 | 46.6 | 8.02 p. m. | 0.48 | ... | 93.4 | 58.6 | Do. |
| GREAT WESTERN RY. | | | | | | | | |
| London Paddington-Bristol Temple Meads. | 191 | 118.3 | 10.00 a. m. | 1.45 | ... | 108.8 | 67.6 | «The Bristolian ». |

the « Coronation » only in the fact that as it reverses at Leeds, whence a tank engine takes it on to Bradford, the observation car, with its 16 seats and mail compartment, has been omitted. The principal characteristics of these streamlined trains are given in Table 14. We have added those of a couple of trains made up of ordinary rolling stock.

Several others have been modernised

as well. The new « Hook Continental » which is to run from next Autumn will comprise 13 carriages including 2 kitchens and 2 Pullman cars. Its length, exclusive of the engine, will be 821 ft. and it is to seat 368 passengers, 84 firsts, 44 in the Pullmans and 240 seconds. The world. It has been accelerated this year so as to accomplish the journey in the round seven hours whilst its relief which leaves London 5 minutes later, and carries through coaches for Perth and Aberdeen, loses 13 minutes at the stations and takes 7 h. 20 m. On Saturdays, a

TABLE. 14.

COMPOSITION OF CERTAIN RECENT BRITISH TRAINS.

| Company. | Name of train. | Number of coaches. | Number of seats. | | | Weight of train (tons) | | Length of train | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1st. | 3rd. | Total. | without locomotive. | with locomotive. | without locomotive. | with locomotive. |
| & N. E. Ry. | The Silver Jubilee (1936) . | 7 | 58 | 125 | 183 | 220 | 386 | 392′ | 462′ 3 1/2″ |
| Do. | The Coronation (1937) . . | 9 | 48 | 162 | 210 | 312 | 479 | 513′ 2 1/2″ | 584′ 1 3/4″ |
| Do. | The West Riding Ltd. (1938) | 8 | 48 | 162 | 210 | 278 | 445 | 459′ 7 1/2″ | 530′ 0 3/4″ |
| M. & S. Ry. | The Coronation Scot (1937) | 9 | 82 | 150 | 232 | 297 | 461 | 540′ | 614′ |
| | **Other trains.** | | | | | | | | |
| & N. E. Ry. | The East Anglian (1937) . | 6 | 54 | 144 | 198 | 219 | 352 | 377′ | 439′ 9″ |
| Do. | The Flying Scotsman (1938). | 12 | 36 | 213 | 249 | 426 | 590 | ... | ... |

*Southern Ry.* is not building new stock but renovating existing trains. New 352-ton, 11-car London and Weymouth trains seat 102 1st- and 408 3rd-class passengers. On busy days an extra composite coach is added, seating 48, half in each class.

The rolling stock used for « The Flying Scotsman », which is probably the most famous train in the world, is renewed periodically so as to make it as up to date as may be. Its usual journey between London and Scotland calls for intermediate stops at Grantham, York, Newcastle and Berwick. During the Summer, a relief train handles this local traffic and the « Flying Scotsman » proceeds non-stop as far as Edinburgh, this being the longest non-stop run in the second relief leaves for Edinburgh 5 minutes after the first.

The « Flying Scotsman » Summer make-up comprises 12 carriages and now includes two dining cars besides two buffet cars for light refreshments. All this has increased its weight to 432 tons.

As there is no relief during the Winter months, the through carriages to places north of Edinburgh are attached to the « Flying Scotsman » which is thus made up to 14 cars holding 60 firsts and 258 thirds, and whose weight reaches 503 tons. Should it comprise 15 or 16 cars, as seems possible, the weight would be nearer 600 tons.

Most of the other named trains with which we have dealt in the *Bulletin* for November 1933 (1) have been maintain-

(1) November 1933, p. 1063 and foll. (81 and foll.).

ed with the usual slight changes traffic has made it expedient to bring to their timings.

The *L. M. S.* has named a few more of its expresses, the latest name « The Centenary » having been bestowed on a London and Birmingham express during the Exhibition held from the 18th to the 25th September 1938, to commemorate the hundredth anniversary of the opening of the first main-line railway (1).

The most important of the new non-streamlined trains, put on since we last reviewed them is, the *Great Western's* « Bristolian ». This Company's « Cheltenham Flyer » the performances of which created such a stir runs to its former schedule and it is only since the 1938 Summer that the *L. and N. E. Ry.*'s « Coronation » has wrested Great Britain's blue ribbon from it.

The greater number of these trains are heavy and so popular that two or more reliefs are often run. Here are a few instances kindly supplied to us by the *L. M. S.* :

During the August Bank Holiday week, « The Royal Scot » ran daily in three sections and in four, on the Saturday.

At the commencement of the Scottish grouse season. « The Royal Highlander » had six reliefs.

On most summer Saturdays, « The Welshman » has two reliefs.

All-Pullman trains such as « The Yorkshire Pullman » often have up to 11 Pullman cars which, with the van, weigh 460 tons. « The Bournemouth Belle » is heavier still.

The same applies to the principal cross-country services. On Saturdays, during the season, there are 5 « Pine Expresses » from Manchester to Bournemouth and 10 « Sunny South Expresses » from Liverpool to Brighton and Eastbourne.

Figure 12 shows all lines having trains

---

(1) The Scottish named trains can be grouped as follows :
Euston to Glasgow : « The Coronation Scot » and « The Night Scot »;
Euston to Glasgow with an Edinburgh section : « The Royal Scot » and « The Mid-Day Scot ».
Euston to the North of Scotland : « The Royal Highlander ».

Besides « The Granite City » the *L. M. S.* runs two other three-hour named trains from Glasgow to Aberdeen. These are the daily « Saint Mungo » and « The Bon Accord », which only runs on certain dates. Saint Mungo is Glasgow's patron saint and « Bon Accord » appears in Aberdeen's coat of arms, hence these names.

Further trains have been added on the Inverness service. Both the Kyle of Lokalsh trains have been retained, whereas the Inverness-Wick « Saint John o'Groat » has had an « Orcadian » added to it.

The *L. M. S.* principal boat trains are :

| | | |
|---|---|---|
| « The Irish Mail » | From Euston | to Holyhead, for Dublin; |
| « The Ulster Express » | Do. | to Heysham, for Belfast; |
| « The Manxman » | Do. | to Liverpool, for the Isle of Man. |

The old *Midland Ry.* services have been revised and speeded up. The two Saint Pancras trains to Scotland, « The Thames and Forth » and « The Thames and Clyde » expresses, have been maintained.

Two other expresses run from St. Pancras to Manchester via Derby, with extensions to Liverpool. These are « The Peak Express » and « The Palatine » from Manchester, taking 3 h. 35 m. and 3 h. 56 m. respectively.

On their Irish *Northern Counties Committee* lines, the *L. M. S.* runs « The North Atlantic Express » and « The Portrush Express » between Belfast and Portrush.

whose average speed is over 62 m.p.h. The *Great Western*'s contribution consists, besides its old main line, of bye passes and branches that spring from it in various places, all of which can now be considered as main lines. Distances will be found in the footnote (1).

EXCEPTIONAL RUNS. — Technical research has been applied to speed and very high speeds have been reached in practice. It would be unwise to attach too much importance to exceptional runs but the fact of their having actually been made in everyday service is worthy of note. On the other hand one should not go to the other extreme and simply consider them as a sporting event. In the past, exceptional runs have always forecast actual performances : to day's exceptional performance may become to morrow's everyday practice.

On 3rd July last, one of the *L. and N. E. Ry.* trains maintained, over a distance of 5 miles between Bytham and Essendine (on the Peterborough-Grantham section), an average speed of 120 m.p.h. and even reached a maximum of 125 m.p.h. This is the first time this speed has been reached by a steam locomotive and properly authenticated.

A German 4-6-4 streamlined locomotive had previously very nearly reached as high a figure, having attained 124.5 m.p.h. between Berlin and Hamburg. But the *L. and N. E.*'s performance is the only one accurate details of which available (2). These are not exceptional runs in the sense of experimental ones. They prove that with ordinary everyday rolling stock and locomotives running on a track built and maintained in the usual way, such high speeds can be reached without danger and without any undue wear and tear. In everyday practice, a speed of 90 m.p.h., which is not unusual in England, is not exceeded and seems to be the present speed limit of British trains.

*Ib.* Ireland. — Whilst the *Great Northern (I.) Ry.* has slackened its best

---

(1) Brunel's main line ran from Paddington to Bristol (118 1/4 miles) via Bath (106 3/4 miles), and on to Taunton (163 1/4 miles) and Plymouth (246 miles).

A long bye-pass leaves it at Reading (36 miles), and through Westbury (95 1/2 miles) joins it again at Taunton (143 miles) instead of the original 163 1/4 miles, thus shortening the total distance to all places west of Taunton by 20 1/4 miles.

« The Cheltenham Flyer » and « The Bristolian » run along the old line; « The Cornish Riviera Ltd. » has been transferred to the new over which « The Torbay Express » also runs.

The South Wales main line branches off at Swindon (77 1/4 miles) and passes through Badminton (100 miles), just north of Bristol so as to reach the Severn tunnel. A few of the fast Paddington and Bristol trains are diverted via Badminton and keep part of the way to the north of the old main line. There is little to choose between the two as far as mileage goes, the distance from Paddington to Bristol Temple Meads being 117.6 miles via Badminton and 118.3 via Bath. The fastest trains take 105 minutes over both routes, the average speed being 67.2 and 67.6 miles an hour.

There are 10 1/4 miles from Didcot (junction with the old line, 53 1/4 miles) to Oxford.

(2) The « Mallard » streamline *Pacific* locomotive hauled 7 carriages weighing 236 1/2 tons empty and 240, in service.

It has been stated that an American locomotive ran at 127 m.p.h. in 1906, but this has not been authenticated and no details are available.

On 27th September 1936, the locomotive « Silver Link » of the *L. N. E. Ry.* reached a speed of 112.5 m.p.h. with a 270-ton test train; it then maintained a sustained average speed of 100 m.p.h. over a 43-mile section.

On 29th June, 1937, the *L. M. S. Ry.*'s « Coronation » bettered this with 114 m.p.h.

runs which no longer reach the mile a minute standard, the *L. M. S. Northern Counties Committee* has been accelerating its crack trains. Its « North Atlantic Express » now holds Ireland's record and reaches the 60 m.p.h. goal which all British railways seek to attain (1).

II. **France.** — In spite of French railcar progress and the inroads electric traction is making on steam, the progress of French steam locomotives needs careful watching as Mr. Chapelon's wonderful improvements have clearly shown. On other lines, novel and sometimes revolutionary types are being tried out and there is no doubt that even classical design is fitting steam locomotives for a further lease of life.

Apart from their use for hauling heavy trains on electrified sections, they have an advantage that neither diesels nor electric locomotives can ravish them. They can operate under much more varied conditions than their competitors for, as the French say, « they are more elastic ». This applies in particular to passenger traffic. The number of seats of every diesel car or rake is permanently fixed (save in the still exceptional case of multiple-unit working), and this is not the case for locomotive-hauled trains. As an example, we would refer to the withdrawal of the Paris and Brussels diesel triplets which were always overcrowded and had to allow steam trains to be substituted for them. The same has occurred on the Rouen-Le Havre local services previously worked by diesels that could no longer cope with the traffic they themselves had fostered, so that the steam locomotive has reappeared in their stead.

The question of train capacity has further been strikingly illustrated on the former *P. L. M.* where the Paris-Marseilles streamlined train was always overcrowded (2). An ordinary dining-car train seating 312 instead of 192 has taken its place and 5 extra minutes only have been allowed over the entire 863 km. (536 miles) of the route. It now takes 9 h. 10 m. instead of the previous 9 h. 5 m. for the much lighter train. And one wonders in this connection, whether the advantages of streamlining have not been over-estimated in many instances. Is it reasonable to have streamlined a Hungarian locomotive for maximum average speeds of 56.5 m.p.h.? And doesn't the *P.L.M.*'s experience call for reserved comment ?

This change-over has had far reaching results on the French South Eastern Region. As the number of available (and most uncomfortable) seats on the *P.L.M.*'s Paris-Lyons Bugatti multiple-unit railcar was insufficient, it has been withdrawn in favour of the streamlined steam train which, after all, seats more people, and the schedule has been eased out by 26 minutes one way, 20, the other, including, it is true, an extra stop at Mâcon. The Bugatti has been re-employed elsewhere and now connects with the Paris rapide at Mâcon so as to provide a fast service to Geneva, which is now brought

(1) Until 1934, the *Great Northern (I.) Ry.* held the record, and ran the 54.3 miles from Dublin to Dundalk in 54 minutes, at 60.3 m.p.h.

This has now been slowed down and the Company's fastest train from Dublin to Drogheda is the 6.40 a.m. which takes, with an average speed of 57.73 m.p.h., 33 minutes for the 31 3/4 miles.

(2) We give its main characteristics in the Appendix, p. 55.

See general description in the *Bulletin* for October 1937, pages 2024 et seq. (836 et seq.).

to within 7 hours from Paris, the shortest time ever obtained.

IV. **Belgium.** — See Chapter I.

V. **The Netherlands.** — The steam services alone have not been improved in the May timetables. In fact, many of them and even heavy internationals hauled by steam locomotives over electrified lines have been slowed down.

The fastest steam run is accomplished at just over 55 m.p.h. and the longest, which previously reached 153 km. (95 miles) from Flushing to Eindhoven, has been curtailed to the 119 km. (74 miles) from Flushing to Tilburg.

VI. **Italy.** — See Chapter I.

VIII. **Hungary.** — Whilst looking into diesel operation sponsered by Ganz of Budapest, the *Royal Hungarian State Rys.* have experimentally covered over 4-4-4 tank locomotives (1) dealing with 4 or 5-car trains. Their maximum speed is 75 m.p.h. As the actual average speed does not quite reach 57 miles an hour, one wonders, here again, whether it has served any useful purpose to enshroud these locomotives for running at speeds which are, to say the least, conservative ?

The Railway contends, nevertheless, that the streamlining accounts for 10 p.c. of the 740 B.H.P. indicated capacity which can be increased, temporarily, to 900.

The hourly speeds of the fastest runs made by these streamliners, by Hungarian railcars and by electrically operated trains are very nearly identical :

| | | |
|---|---|---|
| Steam locomotives. . | 90.0 km. | (55.9 miles) |
| Diesel railcars . . . | 91.3 km. | (56.7 miles) |
| Electric traction . . | 91.0 km. | (55.5 miles) |

XIV*b*. — **The Baltic State** Railways run both steam trains and railcars at

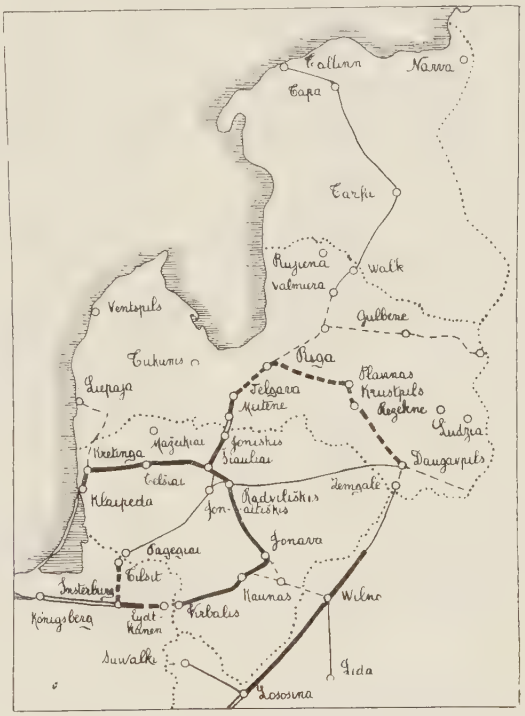



Fig. 11. — Cartogram of maximum average train speeds in the Baltic States. Reference, see fig. 1.

(1) The leading dimensions are :

| | | | |
|---|---|---|---|
| Cylinders . . . . . | 17 in. diam. by 25 1/2 in. stroke | Tractive effort . . . . . | 14 300 lb. |
| Boiler pressure. . . . . | 270 lb. per sq. in. | Wheels, diam. . . . . | 6 ft. 6 3/4 in. and 3 ft. 6 in. |
| Grate area . . . . . | 30 sq. ft. | Water tank capacity. . . | 2 200 gallons. |
| Firebox heating surface. . | 133 sq. ft. | Coal bunker capacity. . . | 4 1/2 tons. |
| Total (evaporative) . . . | 1 293 sq. ft. | Weight, in working order . | 85.3 tons. |
| Superheater . . . . . | 379 sq. ft. | Weight, adhesive . . . . | 29.2 tons. |

over 55 m.p.h. across the limitless plains that continue the Polish ones up to the Russian frontier. As these services are

sels, although its 115.5 km. (71.7 miles) per hour average speed is considerably lower than last year's 125.6 km. (78.1 mi-

TABLE 15.

NOTEWORTHY TRAIN SPEEDS IN THE BALTIC STATES.

| RUN. | Distance. Km. | Miles. | Time of departure. | Time spent. | Speed. Km./h. | M.p.h. | — |
|---|---|---|---|---|---|---|---|
| **Lithuania.** | | | (1) | | | | |
| (Virbalis) Vilkaviskis-Kazlu Ruda. | 32 | 19.9 | 6.57 1/2 p. m. | 0 24 | 80.0 | 49.7 | ... |
| Kazlu Ruda-Kaunas . . . | 37 | 23 0 | 7.22 p. m. | 0.27 | 82.2 | 51.1 | ... |
| Kaunas-Kedainiai . . . . | 73 | 45.4 | 9.54 p. m. | 0.53 1/2 | 81.9 | 50.9 | ... |
| Kedainiai-Radviliskis . . . | 64 | 39.8 | 8.48 1/2 p. m. | 0.46 1/2 | 82.6 | 51.3 | ... |
| Radviliskis-Siauliai . . . | 20 | 12.4 | 7.54 p. m. | 0.14 | 85.7 | 53.3 | ... |
| Siauliai-Joniskis . . . . . | 44 | 27 3 | 9.51 1/2 p. m. | 0.29 1/2 | 89.5 | 55.6 | ... |
| Siauliai-Telsiai . . . . . | 70 | 43.5 | 8.45 a. m. | 0.45 | 93.3 | 58.0 | Railcar. |
| Telsiai-Kretinga . . . . . | 72 | 44.7 | 9 31 a. m. | 0.52 | 83.1 | 51.6 | Do. |
| Kretinga-Klaipeda . . . . | 22 | 13.7 | 9.55 p. m. | 0.15 | 88 0 | 54.7 | Do. |
| **Latvia.** | | | | | | | |
| (Riga) Ogre-Krustpils . . . | 94 | 58.4 | up4.53 a. m. | 1.13 | 77.3 | 48.0 | Broad gauge. |
| Krustpils-Daugavpils . . . | 89 | 55.3 | up3 17 a. m. | 1.08 | 78.5 | 48.8 | Do. |
| Riga-Jelgava . . . . . | 43 | 26.7 | 6.25 a. m. | 0.33 | 75.1 | 46 7 | Standard gauge. |
| Jelgava-Meitene . . . . . | 28 | 17.4 | 6.59 a. m. | 0.21 | 80.0 | 49.7 | Do. |
| **Esthonia.** | | | | | | | |
| Walk Elva-Tartu . . . . . | 83 | 51.6 | up12.41 a. m. | 1.13 | 68.2 | 42.4 | Broad gauge. |

(1) The Lithuanian timetables give the arrival and departure times in minutes and half-minutes.

but little known, we quote all runs at 50 miles and over (1).

XX. Germany. — In spite of the remarkable performances of German railcars Germany has by no means abandoned steam for her fast trains. We have previously referred to the Berlin-Hamburg *FD* train and its streamlined locomotive. It now takes but 9 minutes longer than the fastest, and 3 minutes longer than the slowest of the « Flying Hamburger » diesles), when it held the World record for steam trains.

The *Henschel-Wegmann* streamlined train (2) runs thrice daily from Berlin to Dresden and back but, with one exception, all the runs have been decelerated. The same trend is to be observed in many, if not in the majority, of the fast steam train timings.

Two further *FD* trains have been added to those we have previously quoted (3). We tabulate them in Table 16

(1) In Lithuania the timing is given in minutes and half-minutes.

(2) See characteristics, table 24.

(3) See *Bulletin of the Railway Congress* for August 1937, p. 1734 (764).

TABLE 16.

GERMAN STREAMLINED FD TRAINS.
Non-stop runs shown in **heavy** type.

| RUN. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Number of stops. | Speed. Km./h. | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|
| **Radiating lines.** | | | | | | | | |
| erlin Lehrter Bhf.-Hamburg Hbf. | 286.8 | 178.1 | **6.11** p.m. | 2.29 | ... | **115.5** | **71.7** | *FD* train. |
| erlin Zoo-Hanover-Bentheim . | 455.5 | 283.0 | up 11.16 a.m. | 4.58 | 2 | 91.1 | 56.6 | Do. Boat train. |
| Hanover-Osnabrück . . . . | 132.5 | 82.2 | **4.51** p.m. | 1.20 | ... | **99.0** | **61.6** | *FD* train. |
| erlin Zoo-Hamm-Krefeld-Aix la Chapelle. | 622.0 | 386.5 | up 4.03 p.m. | 7.16 | 8 | 86.3 | 53.6 | *FD* train. |
| Berlin Zoo-Hanover. . . . | 254.1 | 157.8 | **2.10** p.m. | **2.34** | ... | **99.0** | **61.5** | Do. |
| Hanover-Bielefeld . . . . | 109.5 | 68.0 | **6.35** p.m. | **1.06** | .. | **99.5** | **61.8** | Do. |
| Berlin Z.) Hamm-Wuppertal-Cologne. | 548.8 | 341.0 | up 4.57 p.m. | 6.22 | 4 | 86.2 | 53.5 | Do. |
| erlin Zoo-Hamm-Duisburg-Cologne. | 578.9 | 359.7 | 3.52 p.m. | 6.36 | 8 | 87.7 | 54.5 | Do. |
| Duisburg-Dusseldorf . . . | 23.7 | 14.7 | **11.37** p.m. | **0.14** | . . | **101.4** | **63.0** | Do. |
| Berlin P.) Potsdam-Magdeburg | 115.8 | 71 9 | **9.19** p.m. | **1.07** | ... | **103.7** | **64 4** | *D* train. |
| Do. Brandenburg-Magdeburg | 80.6 | 50.1 | **up 6 46** a.m. | **0.46** | ... | **105.1** | **65.3** | Do. |
| erlin Anh.-Erfurt-Frankfort . | 549.7 | 341.6 | up 2.40 p.m. | 6.15 | 3 | 87 7 | 54.7 | *FD* train. |
| Berlin A.-Leipzig . . . . | 164.3 | 102.2 | **up 7.18** p.m. | **1.37** | ... | **101.6** | **63.2** | Do. |
| erlin Anhalt-Stuttgart. . . | 662.3 | 411.5 | 9.28 a.m. | 9.20 | 4 | 71.0 | 44.1 | Do. |
| erlin A.-Halle-Augsburg-Munich. | 674.8 | 419.3 | up 12.05 p.m. | 7.57 | 3 | 84.3 | 52.4 | Do. |
| Berlin A.-Halle . . . . . | 161.7 | 100.4 | **10.15** a.m. | **1.36** | ... | **101.1** | **62.7** | Do. |
| erlin A.-Passau-Regensburg-Vienna West. | 928.0 | 576.6 | 7.12 a.m. | 12.03 | 5 | 77.3 | 48.0 | Do. |
| Regensburg-Passau . . . . | 117.6 | 73.3 | **up 12.10** p.m. | **1 13** | ... | **97.0** | 60.3 | Do. |
| erlin A.-Dresden Neustadt. . | 176.0 | 109.3 | **up 9.37** a.m. | **1.35** | ... | **111.2** | **69.0** | Streamline *D* train. |
| Berlin) Liegnitz-Breslau . . | 65.1 | 40.5 | **up 5.57** a.m. | **0.39** | ... | **100.2** | **62.3** | *D* train. |
| **Cross-country services.** | | | | | | | | |
| Amsterdam) Emmerich-Cologne-Basle D. R. B. | 645.9 | 401.4 | 9.37 a.m. | 7.13 | 9 | 89.0 | 55.3 | *FD* tr. « Rheingold» s. tabl.19. |
| Hook) Emmerich-Cologne-Munich. | 768.8 | 477.7 | up 9.18 a.m. | 9.50 | 9 | 78.2 | 48.6 | *FD* train. |

and have added partial runs of interest and, notably, all those accomplished at 62 m.p.h., and over, which now represent 1 076 route-km. (669 route-miles) When comparing these performances with those of the railcars, it should not be lost sight of that whereas the latter are ultra-light strictly limited trains, the *FD* trains frequently weigh 600 tons and more and each of them has a seating capacity equal to that of several of the diesel sets.

TABLE 17.

OVERALL SPEEDS OF THE FASTEST RUNS IN THE DIFFERENT COUNTRIES OF EUROPE.

STEAM TRACTION.

| Serial number. | Country. | Company. | Run. | Distance. Km. | Distance. Miles. | Time of departure. | Time spent. | Speed. Km./h. | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|---|---|
| ... | U. S. A. | *Milwaukee.* | *New Lisbon-Portage* . . . . | *69* | *42.9* | ... | *0.35* | *118.9* | *73.9* | « *The Hiawatha* ». |
| 1 | Great Britain. | London & N.E.Ry. | King's Cross-York . . . . . | 303 | 188.2 | 4.00 p.m. | 2.37 | 115.7 | 71.9 | « The Coronation ». |
| 2 | Germany. | Reichsbahn. | Berlin Lehrter Bhf.Hamburg . | 287 | 178.1 | 6.11 p.m. | 2.29 | 115.5 | 71.7 | ... |
| ... | *Great Britain.* | *Great Western Ry.* | *Paddington-Swindon* . . . . | 124 | 77.3 | *up 13.55* p.m. | *1 05* | *114.9* | *71.4* | «The Cheltenham Flyer». |
| 3 | France. | National Rys. Co. | (Paris) Poitiers-Angoulême . | 113 | 70 0 | 2.40 p.m. | 1.00 | 113.0 | 70.0 | The « Sud Express ». South Western region. |
| ... | *Do.* | *Do.* | *(Paris) Valence-Avignon.* . . | *124* | *77.3* | *6.34* p.m. | *1 08* | *109.8* | *68.2* | «Côte d'Azur Express». South Eastern region. |
| 4 | Belgium. | National Rys. Co. | Brussels Midi-Ostend . . . . | 114 | 70.8 | 11.54 a.m. | 1.03 | 108.5 | 67.4 | ... |
| ... | *France.* | *National Rys. Co.* | *Strasbourg-Metz* . . . . . | *155* | *95.6* | *10.29* a.m. | *1.28* | *104.9* | *65.2* | *The « Edelweiss » ex-Alsace-Lorraine.* |
| ... | *Great Britain.* | *L. M. & S. Ry.* | *Watford Jn-Rugby.* . . . . | *105* | *65.1* | *up 6.58* p.m. | *1.00* | *104.7* | *65.1* | ... |
| ... | *Do.* | *Do.* | *Paris Nord-St. Quentin* . . . | *153* | *95.1* | *1.35* p.m. | *1.28* | *104.3* | *64.8* | *Northern region.* |
| ... | *Do.* | *Do.* | *Paris Est-Troyes* . . . . | *167* | *103.8* | *7.10* a.m. | *1.37* | *103.3* | *64.2* | *Eastern region.* |
| 5 | Italy. | State. | (Milan) Verona-Padua . . . | 83 | 51.3 | 9.54 a.m. | 0.49 | 101.6 | 62.8 | ... |
| ... | *France.* | *National Rys. Co.* | *Paris St. Lazare-Rouen* . . . | *140* | *86.6* | *10.15* a.m. | *1 23* | *101.2* | *62.6* | *Western region.* |
| 6 | Northern Ireland. | L.M.&S. (N.C.C.). | Ballymena-Belfast . . . . . | 50 | 31.0 | 8.52 p.m. | 0.31 | 96.6 | 60.0 | « North Atlantic Exp. ». |
| ... | *Great Britain.* | *Southern Ry.* | *Waterloo-Andover Jn.* . . . | *107* | *66.4* | *up 10.00* a.m. | *1 08* | *94 3* | *58.6* | ... |
| 7 | Poland. | State. | Posznan-Zbaszyn. . . . . | 75 | 46.6 | 5.16 p.m. | 0.48 | 93.8 | 58.2 | The « Nord Express ». |
| ... | Ireland. | Gt. Northern. | Dublin-Drogheda. . . . . | 51 | 31.7 | 6.40 a.m. | 0.33 | 92.9 | 57.7 | ... |
| 8 | Hungary. | State. | Vamosgyörk-Füzesabony . . . | 38 | 23.6 | up 2.11 p.m. | 0.25 | 90 0 | 55.9 | ... |
| 9 | Lithuania. | Do. | Kretinga-Klaipeda . . . . . | 44 | 27.3 | 9.51 p.m. | 0.29 | 89.5 | 55.6 | ... |
| 10 | Netherlands. | Netherlands Rys. | Amersfoort-Zwolle . . . . . | 67 | 41.4 | 7.47 a.m. | 0.45 | 89.1 | 55.2 | ... |
| 11 | Czechoslovakia. | State. | (Prague) Pardubice-Chocen. . | 34 | 21.2 | up 8.13 a.m. | 0.23 | 88.7 | 54.8 | ... |
| 12 | Rumania. | Do. | Bucharest-Ciulnita . . . . . | 114 | 70.8 | 7.40 p.m. | 1.18 | 87.7 | 54.5 | « Carol I » Express. |
| 13 | Denmark. | Do. | Copenhagen-Korsör. . . . . | 110 | 68.3 | 1.30 a.m. | 1 17 | 85.3 | 53.0 | ... |
| 14 | Portugal. | Portuguese R. Co. | (Lisbon) Entre Campos-Santarem. | 75 | 46.6 | 8.50 a.m. | 0 55 | 83.3 | 51.7 | ... |
| 15 | Latvia. | State. | Meitene-Jelgava . . . . . | 28 | 17.4 | 3.48 p.m. | 0.21 | 80.0 | 49.7 | ... |
| 16 | Finland. | Do. | Riihimaki-Hameenlina. . . . | 37 | 23.0 | up 1.16 p.m. | 0.28 | 79.3 | 49.3 | ... |
| 17 | Sweden. | Bergslagen Ry. | Mellerud-Oxnered . . . . . | 41 | 25.5 | 12.48 a.m. | 0.32 | 77 0 | 47.8 | ... |
| 18 | Jugoslavia. | State. | (Belgrade) Ralja-Lapovo . . | 77 | 47.8 | 8.25 a.m. | 1.03 | 73.5 | 45 7 | The « Simplon Orient Express ». |

LONGEST NON-STOP RUNS IN THE DIFFERENT COUNTRIES OF EUROPE.

STEAM TRACTION.

| Serial Number. | Country. | Company. | Run. | Distance. Km. | Distance. Miles | Time of departure. | Time spent. | Speed. Km./h. | Speed. M.p.h. | — |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Great Britain. | London & N.E.Ry. | King's Cross-Edinburgh | 632 | 392.7 | 10.00 a.m. | 7.00 | 90.3 | 56.1 | «The Flying Scotsman». |
| ... | *Do.* | *L. M. & S. Ry.* | *Euston-Carlisle* | *481* | *299.1* | *1.30* p.m. | *4 43* | *102.1* | *63.4* | « *The Royal Scot* ». |
| 2 | France-Belgium | National Rys. Co. and Nord-Belge Co. | Paris Nord-Liége Guill. | 367 | 226.7 | 7.15 p.m. | 3.57 | 92.9 | 57.4 | The « Nord Express ». |
| 3 | Germany. | Reichsbahn. | Halle-Nuremberg | 314 | 195.1 | up 2.10 p.m. | 4.08 | 76.3 | 47.4 | ... |
| ... | *Great Britain.* | *Great Western Ry.* | *Paddington-Newton-Abbot (Plymouth)* (1). | *312* | *193.7* | *10.30* a.m. | *3.13* | *96.9* | *60.2* | « *The Cornish Riviera* ». |
| ... | *France-Belgium* | *National Rys. Co. and Nord-Belge Co.* | *Paris N.-Brussels M.* | *311* | *193.1* | *6.10* p.m. | *3 00* | *103.7* | *64.4* | *The « Bluebird ». Northern region.* |
| ... | *France.* | National Rys. Co. | *Paris Nord-Dunkirk* | *305* | *189.5* | *9.50* p.m. | *3.22* | *93.5* | *58.1* | *Do.* |
| ... | *Do.* | *Do.* | *Paris-Montp.-Saumur* | *286* | *177.4* | *12.00* noon | *3.30* | *81.7* | *50.8* | *Western region.* |
| ... | *Do.* | *Do.* | *(Paris Est)-Troyes-Belfort* | *276* | *171.7* | *9.53* a.m. | *3.02* | *91.1* | *56.6* | *Eastern region.* |
| ... | *Germany.* | *Reichsbahn.* | *Erfurt-Frankfort* | *269* | *163.5* | *up 2.40* p.m. | *3.00* | *87.3* | *54 2* | ... |
| ... | *Do.* | *Do.* | *Berlin Zoo-Hanover* | *254.1* | *157.8* | *2.10* p.m. | *2.34* | *99.0* | *61 5* | ... |
| ... | *France.* | *National Rys. Co.* | *Paris St. Lazare-Caen.* | *239* | *148.4* | *up 1 02* p.m. | *2.52* | *83.3* | *51.8* | *Western region.* |
| 4 | Italy. | State. | Milan Cent.-Bologna | 219 | 134.3 | 2.50 p.m. | 2.38 | 83.2 | 51.0 | ... |
| ... | *France.* | *National Rys. Co.* | *Dijon-Lyons Perrache.* | *197* | *122.4* | *1.46* p.m. | *1.58* | *100.2* | *62.3* | *South Western region.* |
| 5 | Poland. | State. | Warsaw Gl.-Bialystok. | 183 | 113.7 | up 11.02 a.m. | 2.02 | 90 0 | 55.9 | The « Nord Express ». |
| ... | *Great Britain.* | *Southern Ry.* | *Waterloo-Bournemouth* | *174* | *108.1* | *4.30* p.m. | *1.56* | *89.9* | *55.9* | « *Bournemouth Ltd.* ». |
| 6 | Belgium. | National Rys. Co. | Namur-Luxembourg | 164 | 101.9 | up 1.25 p.m. | 1.54 | 86.3 | 53.6 | The « Edelweiss ». |
| 7 | Denmark. | State. | Copenhagen H-Nyköbing F. | 155 | 95.6 | up 4.33 a.m. | 2.15 | 68.9 | 42.8 | ... |
| ... | *France.* | *National Rys. Co.* | *Strasbourg-Metz.* | *155* | *96.3* | *10.29* a.m. | *1.28* | *104.5* | *65.2* | *Do. Eastern region.* |
| 8 | Czechoslovakia. | State. | Bratislava-Szob | 150 | 93.2 | 5.13 p.m. | 1.58 | 76 3 | 47.4 | The « Orient Express ». |
| 9 | Ireland. | Gr. Southern Rys. | Kingsbridge-Thurles | 139 | 86.4 | 10.15 a.m. | 1.48 | 77 2 | 48.0 | ... |
| ... | *France.* | *National Rys. Co.* | *Angoulême-Bordeaux St. Jean.* | *134* | *83.3* | *up 2.18* p.m. | *1.24* | *96.7* | *60.1* | The « Sud Express ». *South Western region.* |
| 10 | Sweden. | State. | Langsele-Bräcke | 131 | 81.4 | up 9.51 p.m. | 1.48 | 72.8 | 45.2 | ... |
| 11 | Rumania. | Do. | Sighisoara-Brasov (Bucharest). | 128.6 | 79.8 | 7.10 a.m. | 1.55 | 67.1 | 41.7 | The « Orient Express ». |
| 12 | Netherlands. | Netherlands Rys. | Flushing-Tilburg | 121 | 75.2 | 6.08 p.m. | 1.31 | 80.1 | 49.7 | ... |
| 13 | Finland. | State. | Haapamaki-Seinajoki | 118 | 73.3 | up 7.30 a.m. | 2.05 | 56.7 | 35.2 | ... |
| 14 | Jugoslavia. | Do. | Novska-Dugo Selo-Zagreb | 118 | 73.3 | 3.59 a.m. | 1.41 | 70.1 | 43.6 | The « Simplon Expr. ». |
| 15 | Hungary. | Do. | Nagykanitza-Szombathely | 113 | 70.2 | 10.35 p.m. | 1 34 | 71.5 | 44 4 | ... |
| 16 | Norway. | Do. | God-Hönefoss. | 113 | 70.2 | 4.48 a.m. | 2.07 | 53.4 | 33.1 | |
| 17 | Portugal. | Portuguese R. Co. | Lisbon-Entroncamento. | 108 | 67.1 | 2.10 p.m. | 1.13 | 88.8 | 55 2 | ... |
| 18 | Hungary. | State. | Budapest Keleti-Szolnok. | 100 | 62.1 | 11.55 p.m. | 1.35 | 63.2 | 39.3 | ... |
| 19 | Latvia. | Do. | (Riga) Ogre-Krustpils | 94 | 58.4 | 4.53 p.m. | 1.13 | 77.3 | 48.1 | ... |
| 20 | Lithuania. | Do. | Kaunas-Kedainiai | 73 | 45.4 | 7.54 p.m. | 0 53½ | 81.9 | 50.9 | ... |

(1) Service stop. The 364 km. (226.2 miles) from Paddington to Plymouth are covered in 4 hours, at an average speed of 90.6 km./h. (56.3 m.p.h.).

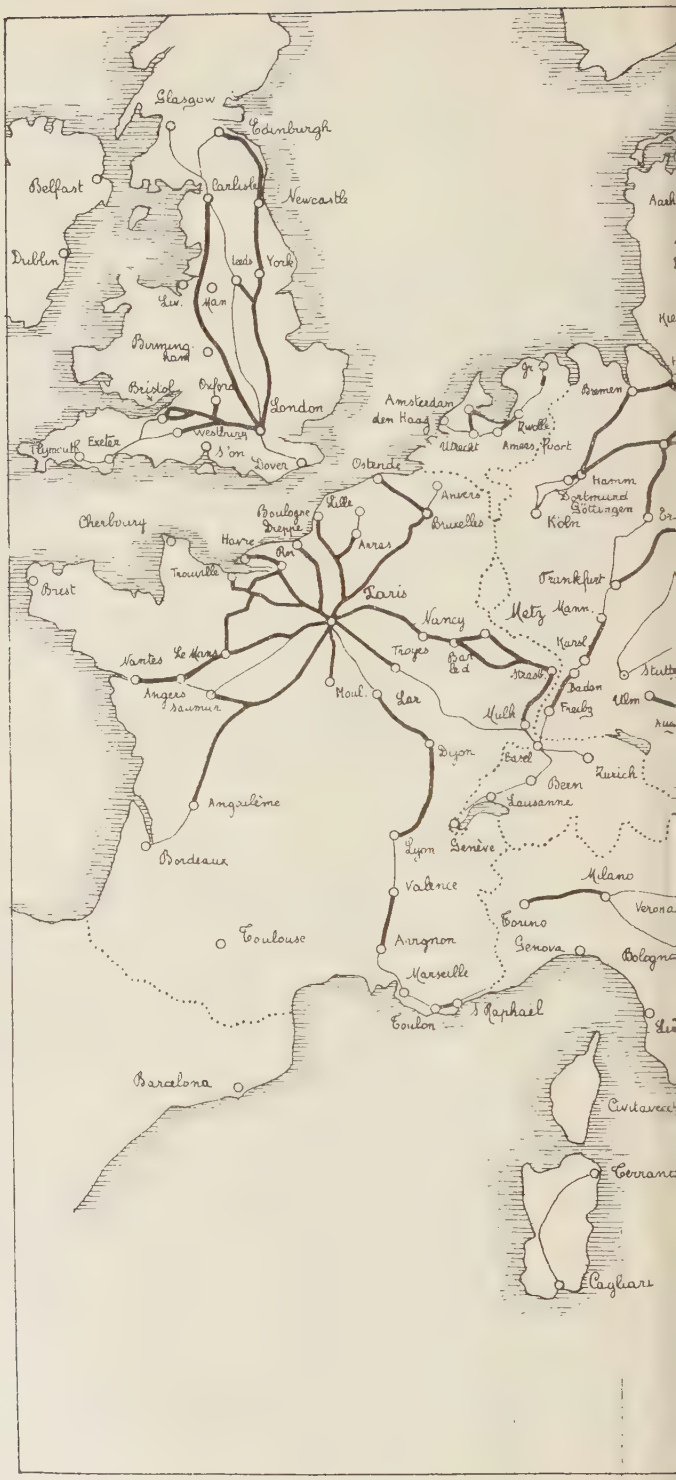



Fig. 12. — European railways having runs at over 100 km. (62 miles) an hour average speed.

The Halle-Magdeburg 86-km. (55 miles) section is also covered at this speed.

ERRATUM. — Owing to an oversight, the frontier between France and Belgium has been omitted.

XXI. **Europe.** — Table 17 gives the main characteristics of the fastest run to be found in each country. As every British main-line Company is as much a separate entity as is any Continental State Railway Administration, we have supplied the same information for each of them, but have indicated all except the fastest of the four, in italics. We have also headed the list, in italics again, with the fastest of the American runs. Four countries — the United States, Great Britain, Germany and France — have runs at over 68 m.p.h. and two others, — Belgium and Italy — at over 62 miles.

Table 18 gives similar information concerning longest non-stop runs. As with the fastest European runs, Great Britain heads the list and, in this case, holds the World record. A Franco-Belgian run is above, and a German, just below the 200-mile limit, with Italy next, under 150.

## CHAPTER V.

### Special services.

In this Chapter, we group those services that differ from the usual railway train. Sleeping- and dining-car services belonging to the *International Sleeping-Car Co.*, the *Mitropa*, the *Swiss Restaurant Car Co.*, or maintained by the Railways themselves, fall under this heading as do train ferries (passengers and goods stock).

A. **The International Sleeping-Car Co.** — As new long-distance railcar services appear, the Company works their buffets, but does not supply any rolling stock for the purpose as it does for ordinary dining-car services. The same applies to

27 couples of electric multiple-units now running on the Dutch lines.

No new « trains de luxe » have been created, nor has any change been brought to existing ones. But the « Paris-Rome Express » will be diverted from November next to the new electrified Pisa-Rome line, proceeding via Civitavecchia instead of through Florence, and the route of the « Simplon-Orient Express » is to be altered in two stages, on its way through Jugoslavia and Rumania (1).

B. The **Mitropa** now runs a second all-sleeping-car train. The Berlin-Munich one has been retained and a Berlin-Regensburg-Vienna one added to it. It takes 13 h. 15 m. on the outward, 13 h. 30 m. on the return journey.

But the Company's principal effort has been brought to bear on the « Rheingold Express » which is provided with new stock and considerably accelerated over the entire German run. Passengers from England or Holland can thus reach Basle much earlier and any point in Switzerland the same day, the same advantages accruing in the reverse direction. It is intended to extend the run from Basle to Milan which would also be reached the same day.

Competition between the « Rheingold » and the « Edelweiss » used to be keen and there was little to choose between the two in point of time, though the advantage was slightly in favour of the latter. In spite of its negociating a much harder route, it took 33 (or 24) minutes less to cover 39 km. (24 miles) more.

The new German timing has reduced the « Rheingold »'s journey by 60 minutes one way and 65 minutes the other, and several of the partial runs include, for the first time, average speeds of over 100 km. (62 miles) per hour. On the other hand, an extra stop has been inserted at Coblence, between Cologne and Frankfort.

Table 19 gives comparative characteristics of the overall and partial « Rheingold » and « Edelweiss » runs. The « Rheingold »'s overall speed is now the higher and it seems difficult for the « Edelweiss » to further improve its own save, perhaps, whilst crossing the Grand Duchy of Luxembourg.

---

(1) It now runs northwards from Vinkovçi to Subotica near the Hungarian frontier (82nd mile from Vinkovçi), then proceeds through Dragutinovo, Kikinda (Jugoslavia) and Jimbolia (Rumania) and joins with the Rumanian main Bucharest line at Timisoara (179th mile) passing beyond, through Turnu Severin (310th mile).

Henceforward, the train is to run to Belgrade (98th mile from Vinkovçi) and will temporarily join the Rumanian line at Timisoara (197th mile by this route), passing through Vrsac (Jugoslavia), and Moratita (Rumania). This is 18 miles longer than formerly but passes through the Jugoslavian capital. A good deal remains to be done so as to render this route practicable for anything like decent speeds. As things stand, the trains would proceed along the Port lines from the present Belgrade main terminal to the Danube station and thereafter follow the Pançevo and Vrsac branch line which would have to be entirely relaid and regraded.

Another project is better, but would require more work still and would take several years to materialise. This would consist in using the Pozarevac Kucevo branch beyond Belgrade, Kucevo being at the 288th km. (179th mile) from Vinkovçi. The branch would have to be extended by Stubic and Brza Palanka to the Danube, which it would reach at Kladovo, opposite Turnu Severin and a bridge would be built between these two places. The distance by this route would be 398 km. (247 miles), which would shorten the journey as compared with the present route by roughly 100 km. (62 miles).

TABLE 19

COMPARATIVE RUNS OF THE « RHEINGOLD » AND « EDELWEISS ».

| RUN. | Distance. | | Time of departure. | Time spent. | Number of stops. | Speed. | |
|---|---|---|---|---|---|---|---|
| | Km. | Miles. | | | | Km./h. | M.p.h. |
| The « RHEINGOLD », *FD* train. | | | | | | | |
| Amsterdam-Cologne-Basle D. R. B. . | 777 | 482.8 | 7.40 a.m. | 9 30 | 14 | 81.8 | 50.8 |
| Emmerich-Duisburg . . . . . | 68.5 | 42.6 | 9.37 a.m. | 0.42 | ... | 97.8 | 60 8 |
| Duisburg-Dusseldorf. . . . . | 23.6 | 14.7 | 10.20 a m. | 0 14 | ... | 101.1 | 62.7 |
| Mannheim-Karlsruhe . . . . . | 60.7 | 37.8 | 2.08 p.m. | 0.36 | ... | 101.2 | 62.8 |
| Baden Oos-Freiburg (Br.). . . . | 103.0 | 64 0 | 3.06 a.m. | 1 01 | ... | 101.3 | 62.9 |
| The « EDELWEISS ». | | | | | | | |
| Amsterdam-Basle S. F. R. . . . . | 816 | 507.0 | 8 03 a.m. | 10.08 | 11 | 80.5 | 50.0 |
| Namur-Luxembourg . . . . . | 164 | 101.9 | up 1.25 p.m. | 1.54 | ... | 86.3 | 53.6 |
| Metz-Strasbourg . . . . . | 155 | 96.3 | up10.59 a.m. | 1.28 | ... | 104.5 | 64.9 |
| Strasbourg-Colmar . . . . . | 66 | 41.0 | 4.23 p.m. | 0.38 | ... | 104.2 | 64.7 |
| Colmar-Mulhouse. . . . . | 42 | 26.1 | up 9 50 a.m. | 0.25 | ... | 100.8 | 62.7 |

On the 2nd October, 1938, the *Mitropa* is to take over the local Austrian services previously operated by the *International Sleeping-Car Co.*, as they now lie entirely in German territory.

C. The **British Pullman Co.** — After having sold to the *L. M. S. Ry.* the Pullman cars formerly running on the old *Caledonian Ry.*, the *Pullman Co.* has ceded to the *Great Southern Rys.* of Eire, those that ran on that system. It now only operates British Pullman cars on two of the main-line systems (the *Southern* and the *L. N. E. Ry.)* besides a service on the *L. P. T. B.* lines.

Since the appearance of the *L.N.E.Ry.*'s « West Riding Ltd. » running between London, Leeds and Bradford, the « West Riding Pullman Express » from London to Wakefield and Halifax has been withdrawn.

D. **The Swiss Restaurant-Car Co.**, like the *International Sleeping-Car Co.* and the *Mitropa*, runs the « buffet-bars » of the Zurich-Geneva, Zurich-Basle and Basle-Geneva electric light trains.

E. **Railway Companies sleeping- and dining-cars.** — The *Great Western Ry.* runs on Sunday nights an all-sleeping-car train from Penzance to London.

F. **Train ferries.** — As a result of extensive bridge building, several Danish train ferry services have been discontinued.

The Little Belt ferries [1] were the

(1) This were the Middelfart Fredericia *State Rys.* ferry and the *Middelfart Snoghöj* private Ry. ferry.

Tariff distances apply to most of the ferry and bridge routes. The following are tariff and actual mileages :

| | Tariff | | Actual | |
|---|---|---|---|---|
| | Km. | Miles. | Km. | Miles. |
| Middelfart-Fredericia . . . . . | 14.0 | 8.7 | 10.2 | 6.3 |
| Vordingborg-Orehoved . . . . . | 15.0 | 9.3 | 9.2 | 5.7 |
| Nyborg-Korsör. . . . . | 40.0 | 24.9 | 26.0 | 16.2 |
| Aalborg-Nörresundby . . . . . | 5.0 | 3.1 | 2.6 | 1.6 |
| Aarhus-Kolby Kaas-Kalundborg | 160.0 | 99.4 | 89.0 | 55.3 |

TABLE 20.

FASTEST RUNS IN EACH EUROPEAN COUNTRY, AND METHOD OF TRACTION USED IN EACH CASE.

| Serial number. | Country. | Company. | Run. | Distance. | | Time of departure. | Time spent. | Speed. | | Method of traction. | — |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Km. | Miles. | | | Km./h. | M.p.h. | | |
| 1 | Germany. | Reichsbahn. | Hanover-Hamm. . . . . | 176 | 109.4 | 9.19 p.m. | 1.20 | 132 3 | 82.2 | Diesel. | ... |
| ... | *U. S. A.* | *Union Pacific.* | *Grand Island-Columbus* . . | *100* | *62.1* | ... | *0.46* | *131 0* | *81.4* | Do. | « City of Denver ». |
| 2 | France. | National Rys. Co | Paris Nord-Longueau. . . | 126 | 78.3 | 10.25 a.m. | 1.02 | 121.9 | 75.8 | Do. | Northern Region. |
| 3 | Great Britain. | London & N.E.Ry. | King's Cross-York. . . | 303 | 188.3 | 4.00 p.m. | 2.37 | 115.7 | 71.9 | Steam. | «The Coronation». |
| 4 | Italy. | State. | Rome Term.-Naples Merg. . | 210 | 130.5 | 8.14 p.m. | 1.49 | 115.6 | 71.8 | Electric. | « Electrotrain ». |
| 5 | Belgium. | National Rys. Co. | Brussels Midi-Ostend. . . | 114 | 70.8 | 11.54 a.m. | 1.03 | 108.5 | 67.4 | Steam. | ... |
| 6 | Netherlands. | Netherlands Rys. | Driebergen-Ede-Wageningen | 29 | 18.0 | 7.17 a.m. | 0.16 | 108.2 | 67.2 | Diesel. | ... |
| 7 | Denmark. | State. | Odensee-Fredericia. . . . | 63 | 39.1 | up 7.20 p.m. | 0.36 | 105.0 | 65.2 | Do. | ... |
| 8 | Poland. | Do. | Radomsko-Czestochowa . . | 41 | 25.5 | up 7.55 a.m. | 0.24 | 102.5 | 63.7 | Do. | ... |
| 9 | Czechoslovakia. | Do. | (Prague) Brno-Bratislava . | 142 | 88.2 | up 6.00 a.m. | 1.26 | 99.1 | 61.6 | Do. | The « Blue Arrow ». |
| 10 | Rumania. | Do. | (Buc. N.) Pantalimon-Ciulnita. | 93 | 57.8 | 9.49 a.m. | 0.57 | 97.9 | 60.8 | Do. | ... |
| 11 | Switzerland. | Federal. | Geneva-Lausanne . . . . | 60 | 37.3 | 6.30 a m. | 0.37 | 97.3 | 60.5 | Electric. | Light train. |
| 12 | Northern Ireland. | L. M. & S. Ry. (N. C. C.). | Belfast-Ballymena. . . . | 50 | 31.1 | up 8.52 a.m. | 0 31 | 96.6 | 60.0 | Steam. | « North Atlantic Express ». |
| 13 | Lithuania. | State. | (Kaunas) Siauliai-Telsiai . | 70 | 43.5 | 8.45 a.m. | 0.45 | 93.3 | 58.0 | Diesel. | ... |
| ... | Ireland. | Gt. Southern Ry. | Dublin-Drogheda . . . . | 51 | 31.7 | 6.40 a.m. | 0.33 | 92.9 | 57.7 | Steam. | ... |
| 14 | Hungary. | State. | Szajol-Kiujszallas. . . . | 35 | 21.7 | 2.06 p.m. | 0.23 | 91.3 | 56.7 | Diesel. | ... |
| 15 | Sweden. | Do. | Nässjö-Alvesta . . . . . | 87 | 54.1 | 3.27 a.m. | 1.01 | 85.6 | 53 2 | Electric. | ... |
| 16 | Portugal. | Portuguese R. Co. | Entrecampos-Santarem . . | 75 | 46.6 | 8 50 a.m. | 0.54 | 83.3 | 51.8 | Steam. | ... |
| 17 | Latvia. | State. | Meitene-Jelgava. . . . . | 28 | 17.4 | 6.59 a.m. | 0.21 | 80.0 | 49.7 | Do. | ... |
| 18 | Finland. | Do. | Riihimaki-Hameenlina . . | 37 | 23.0 | up 1.16 p.m. | 0.28 | 79.3 | 49.3 | Do. | ... |
| 19 | Jugoslavia. | Do. | (Belgrade) Ralja-Lapovo . | 77 | 47.8 | 8 25 a.m. | 1.03 | 73.5 | 45.7 | Do. | The « Simplon Express ». |
| 20 | Esthonia. | Do. | Walk-Tartu (Tallinn) . . | 83 | 51.6 | up12.41 a.m. | 1.13 | 68.2 | 42 4 | Do. | ... |

TABLE 21

LONGEST NON-STOP RUN IN EACH COUNTRY OF EUROPE AND METHOD OF TRACTION USED IN EACH CASE.

| Serial number. | Country. | Company. | Run. | Distance. | | Time of departure. | Time spent. | Speed. | | Method of traction. | — |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Km. | Miles. | | | Km./h. | M.p.h. | | |
| 1 | Great Britain. | London & N.E.Ry. | King's Cross-Edinburgh . . | 632 | 392.7 | 10 00 a.m. | 7.00 | 90.3 | 56.1 | Steam. | The « Flying Scotsman ». |
| 2 | France-Belgium. | National Rys. Co. and Nord-Belge Co. | Paris Nord-Liége Guillem. . | 367 | 228.1 | 7.15 p.m. | 3.57 | 92.9 | 57.7 | *Do.* | The « Nord Express ». |
| 3 | Germany. | Reichsbahn. | Berlin Schl.-Breslau . . . | 330 | 204.7 | 8.10 p.m. | 2.41 | 122.8 | 76.3 | Diesel. | ... |
| 4 | Italy. | State. | Florence S.M.N.-Rome Term. | 316 | 196.4 | 5.01 p.m. | 3.07 | 101.4 | 63.0 | Electric. | « Electrotrain ». |
| 5 | Hungary. | Do. | Budapest-Vienna East . . | 260 | 161.6 | 7.00 a.m. | 2.57 | 88 2 | 54.8 | Diesel. | The « Arpad ». |
| 6 | Czechoslovakia. | Do. | Prague-Brno . . . . . | 255 | 158.4 | 6.34 p.m. | 2.47 | 91.6 | 56 9 | Do. | The « Blue Arrow ». |
| 7 | Denmark. | Do. | Nyborg-Aarhus . . . . . | 198 | 123.0 | 10.24 a.m. | 2.06 | 94.3 | 58.6 | Do. | The « Kronjiden ». |
| 8 | Poland. | Do. | Warsaw Cent.-Bialystok. . | 183 | 113.7 | up11.02 a.m. | 2.02 | 83.5 | 51.9 | Steam. | The « Nord Express ». |
| 9 | Sweden. | Do. | Bollnäs-Ange. . . . . | 168 | 104.4 | 12.24 a.m. | 2.05 | 80.0 | 49.7 | Electric. | ... |
| 10 | Belgium. | National Rys. Co. | Namur-Luxembourg . . . | 164 | 101.9 | up 1.25 p.m. | 1.54 | 86.3 | 53.6 | Steam. | The « Edelweiss ». |
| 11 | Switzerland. | Federal. | Arth Goldau-Bellinzona . . | 142 | 88.2 | up 7.45 p.m. | 2.04 | 68.7 | 42.7 | Electric. | ... |
| 12 | Ireland. | Gr. Southern Rys. | Kingsbridge-Thurles . . . | 139 | 86.4 | 10.15 a.m. | 1.48 | 77.2 | 48.0 | Steam. | ... |
| 13 | Rumania. | State. | Bucharest N.-Ciulnita . . | 128 | 79.5 | 9 10 a m. | 1.26 | 89.2 | 55.4 | Diesel. | ... |
| 14 | Netherlands. | Netherlands Rys. | Flushing-Tilburg . . . . | 121 | 75.2 | 6.08 p.m. | 1.31 | 80.1 | 49.8 | Steam. | ... |
| 15 | Finland. | State. | Haapamaki-Seinajoki . . . | 118 | 73.3 | up 7.30 a.m. | 2.05 | 56.7 | 35.2 | Do. | |
| 16 | Jugoslavia. | Do. | Novska-Dugo Selo-Zagreb . | 118 | 73.3 | 3.59 a.m. | 1.41 | 70.1 | 43.6 | Do. | The « Simplon Express ». |
| 17 | Portugal. | Portuguese R. Co. | Lisbon-Entroncamento . . | 108 | 67.1 | up10.17 p.m. | 1.40 | 64.8 | 40.3 | Do. | The « Sud Express ». |
| 18 | Latvia. | State. | (Riga) Ogre-Krustpils . . | 94 | 58.4 | up 4.53 a.m. | 1 13 | 77.3 | 48 0 | Do. | ... |
| 19 | Lithuania. | Do. | Kaunas-Kedainiai . . . . | 73 | 45.4 | up 7.54 p.m. | 0.53½ | 81.9 | 50.9 | Do. | ... |

first to go when the road and rail bridge came into use on 15th May, 1935. Next came the Storström bridge, one of the longest in Europe, together with the rebuilding of the Madnedsund bridge dating from 1884, between the Islands of Zealand and Falster (1). The Masnedo-Orehoved ferries therefore ceased to operate from the bridge's opening to traffic on 26th September, 1937. Fifty minutes have therefore been gained by most expresses on the railway journey, with the exception of the night train arriving at Copenhagen at 6.48 a.m. which was considered to be quite early enough.

The improvements brought to the crossing of the Limfjord are less spectacular, but their results are far-reaching.

The western ferry service was opened between Oddesund South and Oddesund North in 1883, on the Struer Thisted section of the Jutland railways. In its stead, a railway bridge 472.50 m. (1 550 ft.) long has been built and opened to traffic in May 1938.

The central Sallinsund ferry, started in 1889 on the Skive Nykbing Mors section, still plies.

The Western crossing, between Aalborg and Nörresundby was always accomplished by a bridge. The original structure 400 m. (1 312 ft.) long, constructed in 1859, being too weak for present day loads, a new bridge was built and inaugurated on the 23rd April, 1938, embodying the unusual feature of incorporating the metallic structure of the Roskildefjord bridge which was dismantled owing to the closing down of that line (2).

## CHAPTER VI.

### Conclusions and comparative results.

All the previous data can be condensed into comparative tables completed by tables of percentages of each country's system run at various average speeds.

We draw particular attention to the continuous spreading of high-speed services that gradually appear in countries previously devoid of them.

*(a)* **Fastest European runs.** — Table 20 shows the fastest run in each European country with the kind of traction used for it.

Railcars account for eight runs out of the twenty countries whose runs we quote, steam for ten, and electric traction, for four only.

Six of the countries having runs at over 60 m.p.h. — Germany, France, Denmark, Poland, Czechoslovakia and Rumania — use diesels for the purpose; three — Great Britain, Belgium and Northern Ireland — steam; and three — Italy, the Netherlands and Switzerland — electricity.

Even considering the United States, the fastest run of all is by German diesels. But the *U. S. A.* run the fastest steam and electric trains, the latter being slightly less quick than the former.

*(b)* **The longest European non-stop runs** of each country are shown in Table 21. Steam has 10 of them to its credit, railcars, five and electricity, three.

Taking countries having runs of 150 miles and over only, we first find two steam locomotive runs, Great Britain, followed by France, heading the list; one

(1) The length of the Storström bridge between abutments is, according to « The Railway Gazette » (22nd Oct. 1937), 10 537 ft. As a comparison, that of the Tay Bridge is given as being 11 653 ft., of which the main steelwork spans account for 10 269 ft.

(2) This bridge was opened in 1928 near Frederikssund, in Zealand for the Ringsted line which was closed in 1936.

TABLE 22.

HIGHEST COMMERCIAL SPEED OF STANDARD-GAUGE EUROPEAN RAILWAY MILEAGES COVERED AT VARIOUS SPEEDS

AND PERCENTAGE OF EACH OF THESE SPEEDS TO THE TOTAL MILEAGE OF EACH COUNTRY.

| Total mileage. | Country. | Miles per hour. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | From / to | 38 / 44.9 | 45 / 49.9 | 50 / 54.9 | 55 / 59.9 | 60 / 64 9 | 65 / 69.9 | 70 / 74.9 | 75 / 79.9 | 80 / 84.9 |
| 799 | Baltic States | 90 | 75 | 270 | 43 | ... | ... | .. | ... | ... |
| | | *11.1* | *9.4* | *29.2* | *5.4* | ... | ... | ... | ... | ... |
| 3 154 | Belgium | 435 | 168 | 503 | 95 | 67 | 71 | ... | ... | ... |
| | | *14.0* | *5.3* | *16.0* | *3.3* | *2.1* | *2.3* | ... | ... | ... |
| 1 667 | Bulgaria | ... | ... | ... | . . | ... | ... | ... | ... | ... |
| 8 401 | Czechoslovakia | 1 527 | 467 | 49 | 158 | 88 | ... | ... | ... | ... |
| | | *18.2* | *5.6* | *0.6* | *1.9* | *0.1* | ... | ... | ... | ... |
| 3 151 | Denmark | 121 | 240 | 186 | 142 | 68 | 37 | ... | ... | ... |
| | | *3.8* | *7.6* | *5.9* | *4.3* | *2.2* | *1.2* | ... | .. | ... |
| 3 507 (not included in total.) | Finland (Broad gauge) | 421 | 146 | ... | ... | ... | ... | ... | ... | ... |
| | | *7.4* | *8.8* | ... | ... | ... | ... | ... | ... | ... |
| 20 542 | France | 2 588 | 1 816 | 1 749 | 1 482 | 1 070 | 1 023 | 766 | 78 | ... |
| | | *12.6* | *8.8* | *8.5* | *7.2* | *5.2* | *5.0* | *3.7* | *0.4* | ... |
| 36 264 | Germany | 6 422 | 3 084 | 2 408 | 1 484 | 1 044 | 479 | 378 | 637 | 110 |
| | | *17.7* | *8.5* | *6.6* | *4.1* | *2.9* | *1.3* | *1.0* | *1.8* | *0.3* |
| 894 | Greece | 168 | ... | ... | ... | ... | ... | ... | ... | ... |
| | | *18.9* | ... | ... | ... | ... | ... | ... | ... | ... |
| 5 118 | Hungary | 969 | 225 | 235 | 212 | ... | ... | ... | ... | ... |
| | | *18.9* | *4.4* | *4.6* | *4.2* | ... | ... | ... | ... | ... |
| 10 295 | Italy | 1 517 | 513 | 860 | 348 | 432 | 151 | 130 | ... | ... |
| | | *14.7* | *5.0* | *8.4* | *3.4* | *4.2* | *1.5* | *1.3* | ... | ... |
| 5 006 | Jugoslavia | 716 | 56 | ... | . . | ... | ... | ... | ... | ... |
| | | *14.3* | *0.6* | ... | ... | ... | ... | ... | ... | ... |
| 1 845 | Netherlands | 423 | 205 | 268 | 135 | 128 | 60 | ... | ... | ... |
| | | *22.8* | *11.1* | *14.6* | *7.3* | *7.0* | *3 3* | ... | ... | ... |
| 1 836 | Norway | 64 | ... | ... | ... | ... | ... | ... | ... | ... |
| | | *4.6* | ... | ... | ... | ... | ... | ... | ... | ... |
| 10 880 | Poland | 1 357 | 218 | 694 | 261 | 190 | ... | ... | ... | ... |
| | | *12.5* | *2.0* | *6.4* | *2.4* | *1.8* | ... | ... | ... | ... |
| 6 523 | Rumania | 678 | 347 | 122 | 248 | ... | ... | ... | ... | ... |
| | | *10.4* | *5.3* | *1.9* | *3.8* | ... | ... | ... | ... | ... |
| 8 401 | Sweden | 1 527 | 1 252 | 608 | ... | ... | ... | ... | ... | ... |
| | | *16.7* | *14.9* | *6.7* | ... | ... | ... | ... | ... | ... |
| 2 245 | Switzerland | 465 | 186 | 342 | { 18 / 11 | { 60 / 37 | ... | ... | ... | ... |
| | | *20.7* | *8.3* | *15.0* | ... | *0.2* | ... | ... | ... | ... |
| 210 | Turkey | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 127 234 | Totals | 19 017 | 8 852 | 8 294 | 4 612 | 3 125 | 1 821 | 1 274 | 715 | 110 |
| | | *14.9* | *6.9* | *6.5* | *3.6* | *2.5* | *1.4* | *1.0* | *0.6* | *0.08* |

TABLE 23.

HIGHEST COMMERCIAL SPEED OF STANDARD-GAUGE EUROPEAN RAILWAY MILEAGES COVERED AT VARIOUS SPEEDS AND PERCENTAGE OF EACH OF THESE SPEEDS TO TOTAL MILEAGE OF EACH COUNTRY.

| Total mileage. | COUNTRY. | Mileage covered at commercial speed equal to or over | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 38 m.p.h. | 45 m.p.h. | 50 m.p.h. | 55 m.p.h. | 60 m.p.h. | 65 m.p.h. | 70 m.p.h. | 75 m.p.h. | 80 m.p.h. |
| 799 | Baltic States | 478<br>*55.1* | 388<br>*44.0* | 313<br>*34.6* | 43<br>*5.4* | ... | ... | ... | ... | ... |
| 3 154 | Belgium | 1 339<br>*43.0* | 904<br>*29.0* | 736<br>*23.7* | 233<br>*7.7* | 138<br>*4.4* | 71<br>*2.3* | ... | ... | ... |
| 1 667 | Bulgaria | 0 | ... | ... | ... | ... | ... | ... | ... | ... |
| 8 401 | Czechoslovakia | 2 289<br>*34.4* | 762<br>*16.2* | 295<br>*10.6* | 246<br>*10.0* | 88<br>*0.1* | ... | ... | ... | ... |
| 3 151 | Denmark | 794<br>*25.0* | 673<br>*21.2* | 433<br>*13.6* | 247<br>*7.7* | 105<br>*3.4* | 37<br>*1.2* | ... | ... | ... |
| 3 507<br>(not included in total.) | Finland<br>(Broad gauge) | 567<br>*16.2* | 146<br>*8.8* | ... | ... | ... | ... | ... | ... | ... |
| 20 542 | France | 10 562<br>*51.4* | 7 974<br>*38.8* | 6 168<br>*30.0* | 4 419<br>*21.5* | 2 937<br>*14.3* | 1 867<br>*9.1* | 844<br>*4.1* | 78<br>*0.4* | ... |
| 36 264 | Germany | 16 046<br>*44.2* | 9 624<br>*26.5* | 6 540<br>*18.0* | 4 132<br>*11.4* | 2 648<br>*7.3* | 1 604<br>*4.4* | 1 125<br>*3.1* | 747<br>*2.1* | 110<br>*0.3* |
| 894 | Greece | 168<br>*18.9* | ... | ... | ... | ... | ... | ... | ... | ... |
| 5 118 | Hungary | 1 641<br>*32.1* | 672<br>*13.2* | 447<br>*8.8* | 212<br>*4.2* | ... | ... | ... | ... | ... |
| 10 295 | Italy | 3 951<br>*38.5* | 2 434<br>*23.8* | 1 921<br>*18.8* | 1 061<br>*10.4* | 713<br>*7.0* | 281<br>*2.8* | 130<br>*1.3* | ... | .. |
| 5 006 | Jugoslavia | 772<br>*14.9* | 56<br>*0.6* | ... | ... | ... | ... | ... | ... | ... |
| 1 845 | Netherlands | 1 219<br>*65.6* | 796<br>*42.8* | 591<br>*31.7* | 323<br>*17.6* | 188<br>*10.3* | 60<br>*3.3* | ... | ... | ... |
| 1 836 | Norway | 64<br>*4.6* | ... | ... | ... | ... | ... | ... | ... | ... |
| 10 880 | Poland | 2 720<br>*25.1* | 1 363<br>*12.6* | 1 145<br>*10.6* | 451<br>*4.2* | 190<br>*1.8* | ... | ... | ... | ... |
| 6 523 | Rumania | 1 395<br>*21.4* | 717<br>*11.0* | 370<br>*5.7* | 248<br>*3.8* | ... | ... | ... | ... | ... |
| 8 405 | Sweden | 3 397<br>*33.3* | 1 870<br>*21.6* | 608<br>*6.7* | ... | ... | ... | ... | ... | ... |
| 2 245 | Switzerland | 1 041<br>*44.2* | 576<br>*23.5* | 390<br>*15.2* | 48<br>*0.2* | 37<br>*0.2* | ... | ... | ... | ... |
| 210 | Turkey | 0 | ... | ... | ... | ... | ... | ... | ... | ... |
| 127 234 | Totals | 47 820<br>*37.6* | 28 803<br>*22.6* | 19 951<br>*15.7* | 11 657<br>*9.2* | 7 045<br>*5.5* | 3 920<br>*3.1* | 2 099<br>*1.6* | 825<br>*0.7* | 110<br>*0.08* |

other country — Italy — uses electricity for its longest, and three others — Germany, Hungary and Czechoslovakia — railcars.

*(c)* **Percentage of each system with various maximum average speeds.** — Whilst a train's average speed is a test of good railway connections or the reverse, the extension of high average speeds to other parts of the system is a better criterion still. The proportion of the entire system they apply to or, in other words, the percentage of total mileage with fast trains running at various maximum average speeds, enables this to be accurately gauged.

We have shown these mileages in Table 22 and have added, in italics, what percentage of the system's entire mileage they represent. These partial mileages — partial from a speed point of view — have enabled us to establish the data of Table 23 which show the mileage of each European standard-gauge system having trains running at or above various average speeds.

It will be noticed that even now, over 60 p.c. of the entire European standard-gauge mileage has no single train running at 60 km. (37.5 miles) per hour, whereas 4.2 p.c., of the total mileage has trains running at 100 km. (62 miles) an hour and over.

Taking the countries separately, there is no doubt that since last May, the Netherlands have the best services. Trains run at over 60 km. (37.5 miles) an hour over two thirds of the system and at 45 m.p.h. over half, whereas in France and Germany, so high a proportion only applies to speeds of 60 km. (37.5 miles) per hour and over.

30 p.c. of the French, the Lithuanian and the Dutch systems has trains whose average speed is 50 m.p.h. or more, but France has a slight lead over the Netherlands for speeds above 56 m.p.h..

For the first time, this year, eight European countries run trains at over 62 m.p.h. Taking them in the order we have always applied, these are :

I. Great Britain (See table 13) ;
II. France (1) ;
IV. Belgium (2) ;
V. The Netherlands (See table 2 and fig. 3) ;
VI. Italy (see table 3) ;
XIV. Poland (see table 7 and fig. 8) ;
XVI. Denmark (3) ;
XX. Germany (see tables 8, 11 and 16, and fig. 9).

---

(1) List of French lines having runs at over 68 miles (109.4 km.) per hour commercial speed :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Paris N.-Longueau . . | 75.7 | Railcar | N. | Poitiers-Angoulême. . | 70.0 | Steam | S.E. |
| Laroche-Dijon, up . . | 74.2 | do. | S.E. | Dijon-Lyons Perr. . . | 66.4 | Railcar | S.E. |
| Paris Est-Nancy, up . | 73.0 | do. | E. | Amiens-Arras . . . . | 68.3 | do. | N. |
| Paris S. Lazare-Rouen | 72.1 | do. | W. | Paris St. Lazare-Trouville Deauville . . | 68.1 | do. | W. |
| Paris N.-St. Quentin . | 71.3 | do. | N. | St.Quentin-Aulnoye,up | 68.4 | do. | N. |
| Nancy-Strasbourg . . | 70.7 | do. | E(A.L.). | Valence-Avignon. . . | 68.2 | Steam | S.E. |
| Paris N.-Arras, up . . | 69.6 | do. | N. | | | | |

Four different systems have each contributed one of the four leading lines.

(2) The fastest Belgian run, accomplished from Brussels Midi to Ostend, at 108.5 km. (67.4 miles) per hour, is quoted in Table 20. Other fast runs are :

Ghent-Bruges, 41 km. (25.5 m.) in 23 minutes; speed 106.9 km./h. (66.4 m.p.h.) ;
Ghent-Ostend, 62 km. (38.5 m.) in 36 minutes; speed 103.3 km./h. (64.1 m.p.h.).

(3) We have quoted these runs on page 22.

With the exception of France, Belgium and Denmark, we have tabulated all runs at over 62 m.p.h. for each country. We append similar information for these three countries in footnotes and have thus quoted all European lines having runs at over 62 m.p.h. These we have shown in figure 12.

The percentage of lines covered at over 62 m.p.h. average speed is higher, in five countries, than Europe's 4.2 p.c. average. First comes France, whose percentage is 2 1/2 times as great, Germany, practically twice and the Netherlands, then Italy followed next in order by Great Britain (1).

2.2 p.c. of the total standard-gauge mileage is run over at over 68 m.p.h. average and these runs occur in four countries only, Germany leading with 6 p.c. of her own mileage, followed by France with 5.6 of hers, Italy, then Great Britain close the list.

Europe's mileage having runs at 75 m.p.h. and over has dwindled to 0.8 p.c., contributed by two countries only : Germany, with 948 miles, which represents 4.6 p.c. of her railways, and France quite a distance behind.

All Europe's 110 miles of railways with runs at 80 m.p.h. average speed are in Germany alone.

Il will be most interesting to compare these figures with next year's and to note their fluctuations thereafter. Apart from actual figures, quite a number of other factors should be considered. The most important concerns the cost of speed but the help the railways derive from it in fighting competition offsets it, though to what extent is an unknown quantity. The same applies to the publicity value of speed, to which we have drawn attention in the very first pages of our serial. One might even add a psychological factor, for there is no doubt, the feeling of speed is as much an asset to the railways as the cleanliness and comfort of their rolling stock, the punctuality of their trains, their freedom from accidents and the facilities of all kinds that are at their patrons' disposal.

## APPENDIX.

**Streamlined trains.** — We have given Table 14, page 35, the main characteristics of the British streamlined trains. Similar characteristics of the French train appear page 38, and page 40, those of the German one. Tables 24 and 25 complete this information as far as American and Mandchukuo streamlined steam trains are concerned.

(1) To complete this information, it is necessary to give similar data concerning the British system whose mileage of 20 121 is about half that of France. This mileage includes 563 miles of railways, representing some 2.8 p.c. of the total, with runs at 62 to 68 m.p.h., and 339 miles or 1.6 p.c. at 68 to 74 m.p.h.

Table 24.

CHIEF CHARACTERISTICS OF STREAMLINE TRAINS IN COUNTRIES OTHER THAN GREAT BRITAIN.

| Company. | Name of train. | Number of carriages. | Number of places. | Weight, tons. | | | |
|---|---|---|---|---|---|---|---|
| | | | | Locomotive. | Rake. | Total. | Per place. |
| French Nat. Rys. Co. (South Eastern region). | Streamline train. | 4 | 228 | 145 | 201 | 346 | 1.518 |
| Reichsbahn. | Henschel-Wegmann. | 4 | 192 | 128 | 125 | 253 | 1.318 |
| Reading. | « The Crusader ». | 5 | 276 | 208 | 225 | 433 | 1.570 |
| Chicago Milwaukee St. Paul & Pacific R.R. | « The Hiawatha ». | 6 | 265 | 240 | 357 | 517 | 2.064 |
| New York Central. | « The Mercury ». | 7 | 175 | ... | 380 | ... | ... |
| Do. | «The XXth Century Ltd.» | 16 | ... | 341 | 1 060 | 1 401 | ... |
| South Manchuria. | « The Asia Express ». | 6 | ... | 204 | 323 | 527 | ... |

Table 25

STREAMLINE STEAM TRAIN SERVICES IN COUNTRIES OTHER THAN GREAT BRITAIN.

| Company. | Name of train. | Total run. | Distance. | | Time spent. | Average speed. | |
|---|---|---|---|---|---|---|---|
| | | | Km. | Miles. | | Km./h. | M.p.h |
| n Nat. Rys. Co. | Streamline train. | Paris-Lyons . . . . . | 512 | 318 | 5.05 | 100.7 | 62.6 |
| *Do.* | *Do.* | *Paris-Marseilles.* . . . . | *863* | *536* | *9.00* | *95.9* | *59.6* |
| Reichsbahn. | Henschel-Wegmann. | Berlin-Dresden Neustadt . | 176 | 109 | 1.34 | 112.3 | 69.8 |
| Reading. | « The Crusader ». | New York-Philadelphia . . | 147 | 91 | 1.45 | 84.0 | 52.2 |
| . Paul & P. R. R. | « The Hiawatha ». | Chicago-Minneapolis . . . | 677 | 421 | 7.00 | 96.7 | 60.0 |
| York Central. | « The Mercury ». | Cleveland-Detroit . . . . | 270 | 168 | 2.45 | 98.2 | 61 0 |
| Do. | «The XXth Century Ltd.» | New York-Chicago . . . . | 1 588 | 987 | 16.00 | 99.2 | 61.6 |
| th Manchuria. | « The Asia Express ». | Dairen-Harbin . . . . . | 943 | 586 | 12 30 | 75.4 | 46.9 |

[ 621.135.2 & 625.214 ]

# Development of roller bearing axleboxes for railway vehicles,

by Dipl.-Ing. F. PETERSEN, Schweinfurt.

(*Glasers Annalen.*)

Types of roller bearing axleboxes at present in use, particularly on light railcars, trailers and tramways, also various types of roller bearing axleboxes for main-line railway vehicles. Progress in the use of roller bearings for inside axleboxes, such as for locomotive carrying axles, etc.

The use of roller bearing axleboxes for rail vehicles of all sizes and of all types has been considerably extended during the past ten years. After trials with various experimental types, definite types for the different categories of vehicles have been evolved, and it is, therefore, opportune to illustrate the present stage in the development of roller bearing axleboxes by some examples of practical application.

Roller bearings were first applied to two types of rail vehicles : *(a)* street cars, or tramways; and *(b)* high-capacity goods wagons, with which the German Reichsbahn undertook elaborate trials some 15 years ago. A description of all the Reichsbahn's experimental types of axlebox is not within the scope of the present article (1), and it is necessary to mention only the few that have survived the test of time.

Amongst the latter was a type similar to one which had previously been put into service on tramway cars, differing from it only in size and a few other details; it has not been used of late by the Reichsbahn for reasons which will be explained later, but on tramway cars and other similar vehicles, its use has assumed considerable proportions.

(1) See LAUBENHEIMER, special issue published by the *Verein Deutscher Ingenieure*, Eisenbahnwesen, 1924.

The essential feature of this box, which is shewn in figure 1, consists in the application of the inside races directly on to the journals, and in the absorption of axial forces by a fixed shoulder on the inside ring of the interior bearing, and a loose shoulder on the inside ring of the exterior bearing. In addition, the bearings in question are provided with cylindrical rollers of the wide medium-weight type and the arrangement of shoulder distance pieces gives the advantage of easy assembly and removal, as shewn in figure 2.

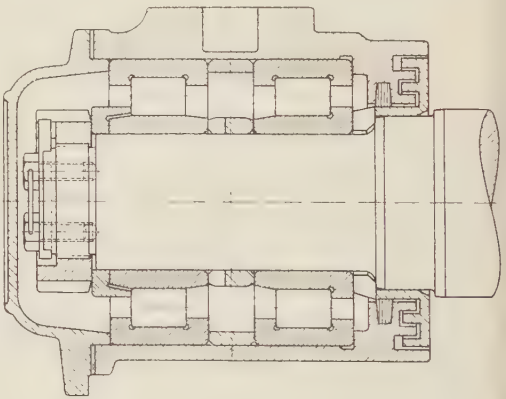


Fig. 1. — Tramcar axlebox.

In fact, after unscrewing the outside cover plate and the collar nut, or the

fastening plate with the cap screws, the box consisting of the outside races with the rollers and cage — which are in a single piece — can be removed by hand, whilst the inside races remain on the journal of the axle, and are not taken off except in cases of defective bearings.

Boxes for use with 70 to 90-mm. (2 3/4" to 3 1/2") journals are standardised for tramways, but this type of box

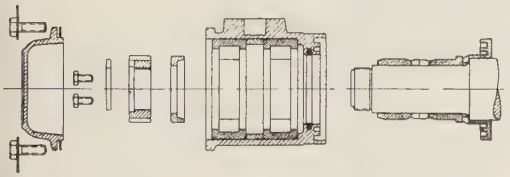


Fig. 2. — Details of tramcar axlebox.

is also used on a large scale for journals with a diameter which may be as large as 100 mm. (3 15/16") and its use has spread, not only to the tramway vehicles, but also to light railcars and trailers working secondary-line or similar services, and to high-capacity ballast and lignite wagons.

Thanks to their excellent tightness they will work very satisfactorily very long periods between greasings. It is true that generally greasing is carried out at the periodical overhaul of the vehicles. It has happened, however, in some cases where, owing to special circumstances, it has not been necessary to withdraw the wheels from the bogies, that the boxes have remained in service over a period of five years without examination or re-greasing. They were in each case in perfect order, and still contained a sufficient quantity of lubricant. As regards the life of the bearings in use on standard tramway vehicles, no definite statement can be made despite the copious information which has been collected, since no way is known of determining the fatigue factor of these parts nor, consequently, of finding their actual life.

There are, in Germany, probably more than 50 000 axleboxes, most of them ten years old and over, in service on tramways, light railcars and ballast wagons, and it is already certain that after being in service for this period, or longer, the bearings are not worn out, so that the approximate values previously obtained by calculation are exceeded in all cases.

With regard to the rolling stock for railway main lines, that is to say, in the first case for those of the German Reichsbahn, two of the early types have survived, and have subsequently been used to a fairly large extent and have also served as a basis for the design of other types now used.

The first of these is a box (figure 3) with two oscillating-roller bearings and two withdrawal sleeves, for journals of

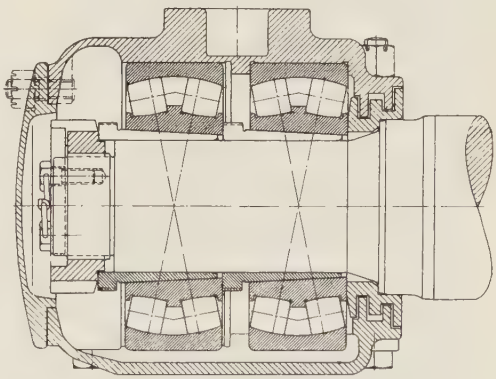


Fig. 3. — Axlebox with oscillating-roller bearings, for main-line vehicles.

110 mm. (4 3/8") diameter. The same box, but provided with cylindrical rollers (figure 4) was subsequently put into service, and this is the reason why the German Reichsbahn gave up using the tramway type mentioned earlier.

After having originally put into service a fairly large number of boxes of the type shewn in figure 3, it was found advisable to retain for the bearings with cylindrical type of rollers the same form

of box, and more particularly, the same design of journal. At the same time, it became possible to allow much greater tolerance to the journal than was given by the design shewn in figure 1, a consideration which formerly played some part in the machining of axle journals.

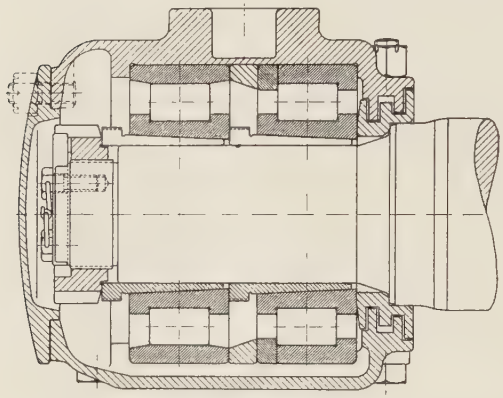


Fig. 4. — Axlebox with cylindrical-roller bearings, for main-line vehicles.

On the other hand, it was not absolutely certain that the inside races bedded directly on to the journal would remain fast in the long run.

By fixing them with conical clamping sleeves, this doubt disappeared since it is permissible, by suitably tightening the sleeves, to obtain a good seating of the races.

The axlebox bodies are in two sections and to dismantle them, after having removed the two halves and the collar nut, the sleeves can be withdrawn by means of special withdrawal nuts. The Reichsbahn workshops are now provided with special arrangements for erecting and dismantling, which have very much simplified these operations (figure 5).

The axlebox equipped with two oscillating-roller bearings presents the advantage that the load is borne uniformly by the four sets of rollers. It should be noted that this uniform load transmission is experienced even though the box has two roller bearings; the differences in the radial play of the two bearings are, however, taken up by the movement of the axlebox bodies (2). In addition, these rollers lend themselves easily to the absorption of axial stresses of practically any value, which is particularly important for heavily loaded axles and high speeds.

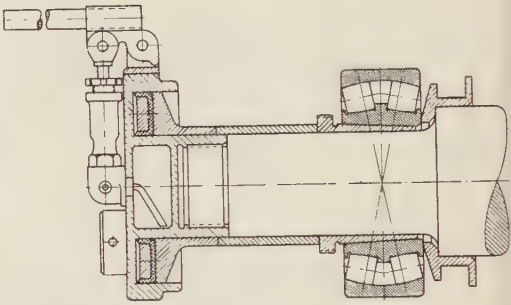


Fig. 5. — Illi hydraulic press used by the Reichsbahn for assembling and dismantling roller bearings fitted with withdrawal sleeves.

With cylindrical roller bearings, the axial stresses are entirely absorbed as sliding friction in the roller guides. These bearings have also proved satisfactory on railway main-line stock.

There remains the question of whether later developments under the operating conditions experienced on the Reichsbahn will make any appreciable differences in the effective lives of these types.

Whilst the designs shewn in figures 3 and 4 are still in service on the Berlin Metropolitan and to a fairly large degree on the corridor coaches for express trains of the Reichsbahn, this Administration has since adopted the type shewn in figure 6, in which the withdrawal sleeve of the inner bearing is dispensed with, the bearing being

(2) See JÜRGENSMEYER, « Die Wälzlager » (Ball and roller bearings), page 198. J. Springer, publisher, Berlin.

mounted directly on to the conical journal.

This gives an increase of 60 % in the moment of resistance in the most dangerous section of the journal, and the alteration was decided upon after several journal fractures had been experienced some years ago with a number of high-capacity goods wagons, the cause of the failures being found out (3).

The latter were progressive fractures due to overloading of the journals, with a simultaneous deterioration of the surface caused by nipping of the edge of the inside withdrawal sleeve.

It was found that on the high-capacity wagons the bearing load and the journal load were not in correct relation to each other.

Whilst the sizes of the bearings were, in accordance with former practice, very small, they have nevertheless shewn a very satisfactory resistance up to the present, and thanks to the conical journal, the security provided at the dangerous section is quite sufficient. In order to avoid superficial damage by the inside edge of the inside ring of the bearing, the journal is designed with a small fillet at this point.

The Reichsbahn regularly uses roller bearings on given types of rolling stock, such as high-capacity wagons, Metropolitan vehicles, and railcars of all types, including the modern high-speed railcars. In addition, a large number of vehicles for high-speed trains (corridor coaches), previously provided with roller bearings, are still in service, and recently this type of bearing has again been used for vehicles working the same services. The differences between the classes of boxes used for the various kinds of rolling stock are naturally concerned with the dimensions of the bearings (although in general only one type is used for the high-capacity wagons, the Metropolitan vehicles and the express carriages), and certain details of the axlebox casing.

So as to give an exactly identical shape to the axleboxes, both with oscillating-roller and cylindrical-roller bearings, the shape of the outside cap was modified so that, apart from the collar placed at the middle of the bore for the oscillating rollers, all parts of the axlebox casings are similar. For high-capacity wagon axleboxes, three pairs of assembly bolts have been used for several years, it being noticed that with the two pairs of bolts formerly used, a certain deformation of the boxes was inevitable, owing to the heavy load they supported (see figure 6). This led to the outside edges of the bearing becoming gradually wedged in the bore of the box, and eventually impairing the fit. The new

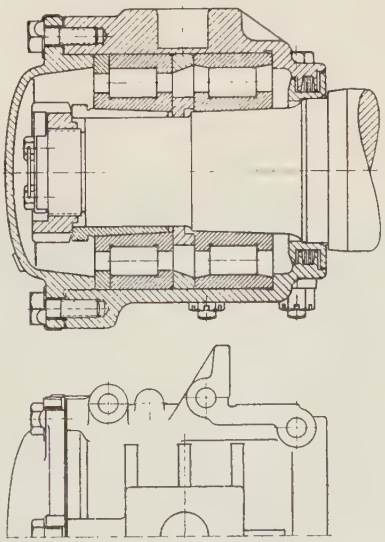


Fig. 6. — Axlebox for high-capacity goods wagon.

(3) See Dr.-Ing. R. KÜHNEL, « Achsbrüche von Eisenbahnfahrzeugen und ihre Ursachen » (Axle fractures and their causes), *Glasers Annalen*, Nos. 1312 and 1313; also Dr. GRABERS, « Die Fahrzeuglager der Deutschen Reichsbahn » (Axleboxes used by the Reichsbahn), *Organ für die Fortschritte des Eisenbahnwesens*, No. 14, 1936.

shape provides a greater rigidity of the box, and thus eliminates the former defect.

There are now so many roller bearings in use on the Reichsbahn that it is possible to say something about the results obtained, and their life in service.

In this respect the same conclusions may be drawn as in the case of the tramway class, that is, the life of the bearings is much longer than was previously supposed. Even for high-capacity wagon axleboxes, in spite of a load of about 10 tons per wheel, and a service of as much as ten years, the proportion of bearings at present requiring renewal is insignifiant. The maintenance is confined to inspection and greasing when the vehicles return to the shops for general overhaul, which on the Reichsbahn is undertaken every 200 000 km. (125 000 miles); one greasing will last up to 300 000 km. (186 000 miles).

A grease, with soda soap base, having a liquefaction point of at least 140° is used, which many years of experience have shewn to be efficient. Statistics shew that the consumption of this lubricant is very small.

As has been mentioned above, the adoption of the conical journal is due to the fact that with the types and sections of the bearings first used, the bearing capacity was not correctly related to the strength of the journals. Moreover, as the conical journal offers the advantage that the greatest strength which can be got coincides with the most highly stressed section, the Reichsbahn decided to retain the conical journal, and to extend its use to all new construction.

There is, of course, another means of ensuring the correct ratio of the permissible stresses in the journal to those in the bearing, which is by reducing the section of the bearing for the same outside diameter and thereby increasing the diameter of the journal. This method was used in other countries and led to the retention of the type shewn above, with two bearings and two withdrawal sleeves, for a cylindrical journal (as in figure 3). With the spring situated above and a normal type of bogie, this box has become the standard outside Germany. Another reason for this is the fact that the machining of cylindrical journals is much easier, which is a considerable advantage in some countries, especially overseas. The use of hard-wearing plates, for example, of 14 % manganese steel, is the rule.

For other kinds of bogies, and particularly those with equalisers or springs situated below the boxes, single bearing axleboxes may be used. Nevertheless, there is no rigid rule, and the solution of this question is dictated by the space available (4).

A single bearing gives the advantage that the housing can be adjusted at will when the bogie is assembled, provided, however, that an adjustable bearing is used — that is to say, an oscillating-roller bearing.

A typical example of this type is that shewn in figure 7, a box fitted on the diesel-electric trains of the Netherlands Railways. The load is carried by equalisers which in turn are supported by cross beams resting on the lower flanges of the axlebox bodies. It will be realised that for a load of 7 tons on the axle journals and a speed which may reach 120 km. (75 miles )an hour, the bearing must necessarily be very robust.

As a result of the relatively great distance between the fulcrum of the equaliser and the middle of the box, the axlebox body is relatively stable, even at high speeds.

The boxes with a single cylindrical roller bearing are generally of use only for moderate speeds and fairly easy service conditions, otherwise the size of

(4) For details of the different possibilities, see Pamphlet on railway axleboxes, issued by *Vereinigte Kugellagerfabriken A. G.*, Schweinfurt.

the bearing support is insufficient, and the pressure on the edges of the bearing becomes excessive. At the same time, if, in the case quoted above, there is only a little space available, boxes with a large cylindrical-roller bearing can be

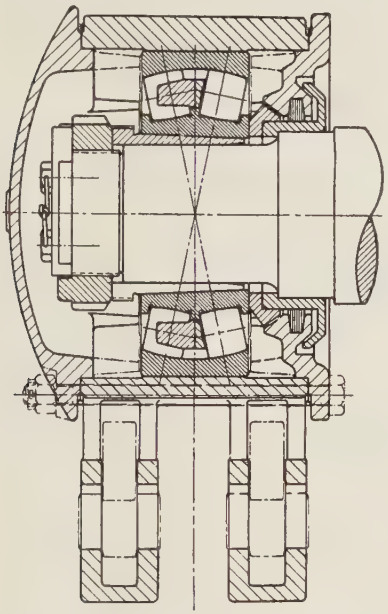


Fig. 7. — Axlebox fitted with oscillating-roller bearings, and equaliser beam placed below the box.

used, as has been done on the Reichsbahn for its well known shunting locomotives.

The axlebox guide in this case should be as near central as possible, so as to avoid unnecessary supplementary stresses tending to make the box tilt.

The single bearing box has, however, a greater importance as an inside box, and warrants a further comment. This is represented by figure 8, which shows an inside box of the leading carrying bogie of a locomotive recently put into service. The particular axlebox illustrated is on the carrying bogie of a heavy passenger and goods locomotive for

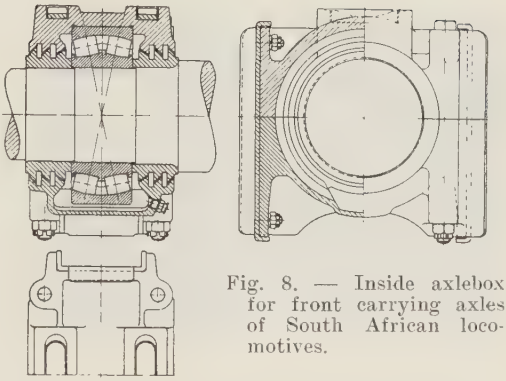


Fig. 8. — Inside axlebox for front carrying axles of South African locomotives.

South Africa. The weight carried on the journal is about 6 tons and the maximum speed is about 85 km. (53 miles) an hour. The essential feature of this arrangement is the fact that the withdrawal sleeves are dispensed with, and the inside pressure ring, with the lateral sealing segments, is pressed on to the axle. The housing is in two parts, which ensures good accessibility of the bearing when subsequent inspection is required. The outside ring can also be removed and by drawing out the rollers, the raceway of the bearing inside ring can be removed.

Examination of the journal is deliberately dispensed with, since the pressure

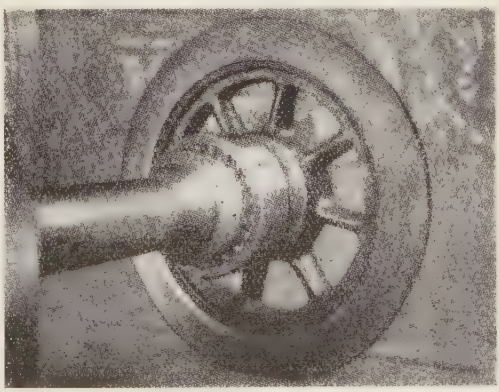


Fig. 9. — Oscillating-roller bearings, as shewn in figure 8, in place.

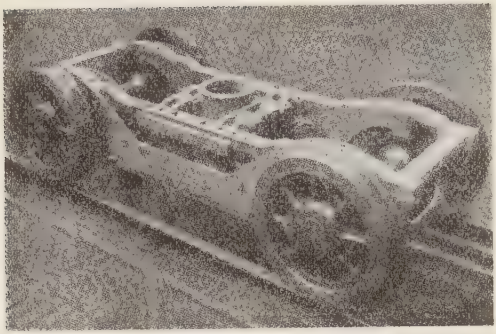


Fig. 10. — Front carrying bogie of locomotive referred to in figs. 8 and 9 (Builders : Henschel und Sohn, Cassel, and Berliner Maschinenbau A. G., formerly L. Schwartzkopff, Berlin-Wildau).

used for fixing the wheels, which are mounted outside, and the use of a single bearing, generally ensure an appreciably larger diameter axle which leaves no doubts at all regarding the permissible stress in the dangerous section.

The sealing is accomplished in such a way that the housing can take up a position markedly oblique to the axle. The housings themselves are provided with wearing plates on the horn cheeks. Other details are given in figure 9 shewing the box in position, and figure 10, shewing the complete bogie.

We are not dealing here with an experimental design, but with one which has been in service in America for several years on some hundreds of locomotives, with satisfactory results. Also, a very large number of the locomotives ordered during recent years by South Africa from Germany have their leading carrying axles equipped with axleboxes of the type described above. It is obvious that in practice absolute safety must be assured, since each defect in the box entails the removal of the wheel for its repair. Experience has shewn, however, that reliability in service is indisputably assured.

With driving and coupled wheels of locomotives, the evolution of the box has not passed the experimental stage. It should be noted, however, that in America there have been for some time, several heavy locomotives in service, provided with roller bearings for the driving and coupled wheels.

The design of these bearings is in principle similar to that described above, with the difference that in order to provide the box with horn cheeks and also with wearing plates in one piece, the top half of the housing is extended downwards on both sides of the bearing (see figure 11).

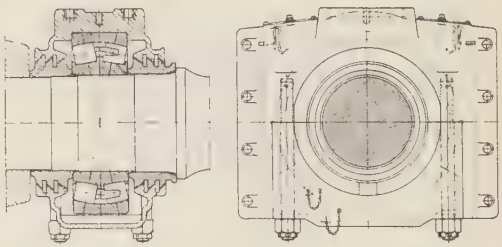


Fig. 11. — Roller bearing box for driving axle of locomotive.

The lower half of the housing is fixed by two pairs of bolts, or by cotters. When the load is applied on top of the housing, and only one bearing is used, there does remain, it is true, a risk of the box rocking, but a certain degree of stability is assured by the ample width given to the upper support. However, with axles having some lateral play, the application of the load would be effected partly outside the axis of the box, and rocking of the latter would be inevitable.

In order to remedy this, the top halves of the housings for a pair of wheels are made in one piece, or the two boxes are connected by an intermediate bolted piece (figure 12).

Of course, the inside box shewn in this diagram is not confined to locomotives, but may be used wherever the me-

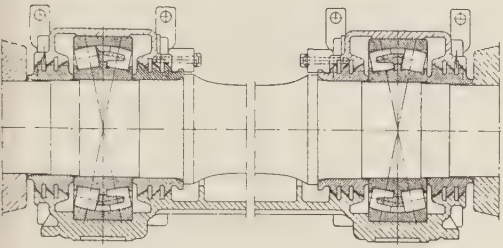


Fig. 12. — Inside axlebox for pairs of locomotive wheels with floating spring support.

thod of construction of vehicles necessitates the use of inside axleboxes, as in the case of certain heavy wagons privately owned.

As is known, the Reichsbahn has up to the present only carried out a trial on one of the new streamlined locomotives, utilising for the forward carrying axles a different type from that described above.

Two bearings have been mounted side by side, on sectional withdrawal sleeves, so as to reduce the outside diameter of the whole. Further, for reasons of security in service, it has been found desirable to use two bearings of a lower carrying capacity, rather than rely on a single one (5).

A similar method was used in Poland on a new express locomotive which was shewn in 1937 at the International Exhibition in Paris. Figure 13 shews certain details of the construction of the boxes for the forward carrying axle. The load on the journals is about 6 tons, and the maximum speed is about 140 km. (87 miles) an hour. Each box is provided with two 22 236 K. bearings; the diameter of the journals is 160 mm. (6 5/16").

The arrangement of the outside roller boxes of the rear carrying axles of the locomotives is generally the same as for

(5) See Dr. WAGNER : « 2C2 Stromlinienlokomotive der Deutschen Reichsbahn » (The German Reichsbahn's 4-6-4 streamlined locomotives). *Organ für die Fortschritte des Eisenbahnwesens*, No. 3. 1936.

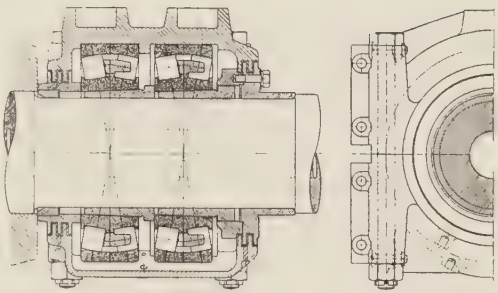


Fig. 13. — Front carrying axlebox with two oscillating-roller bearings, fitted on the new Polish State streamlined locomotive.

other railway vehicles, except that the housing is given a special form having regard to the curve negociation by the pair of wheels (as, for example, in the case of a Bissel truck). An example of this is shewn in figures 14 and 15, which shew boxes for rear carrying axles of the most recent series of locomotives for South Africa. The monobloc housings are provided with lateral brackets, cast on, for fixing the radius bar, and with bearing plates put at an angle above.

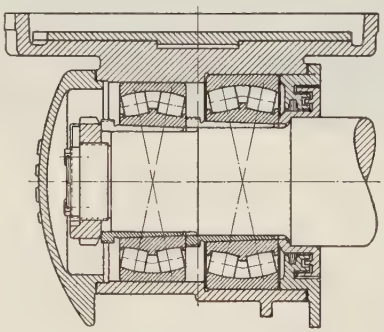


Fig. 14. — Rear carrying axlebox for South African locomotive.

For locomotive tenders the same exterior boxes as for other railway vehicles are usually found. In this case, the types described above would consequently be used, it being understood that account has to be taken of the pos-

sible load, and consequently, of the dimensions of the bearing and the diameter to be given to the journals.

In countries outside Germany, conical roller bearing axleboxes are met with. On account of the conical shape of the rollers and the races, two rows have to be used in every case. The radial play in this type is taken up by adjusting rings when the boxes are assembled. Consequently the assembly must be carried out with the greatest care; further, the parts once assembled, must not be interchanged. In Central Europe these conical roller bearings have not met

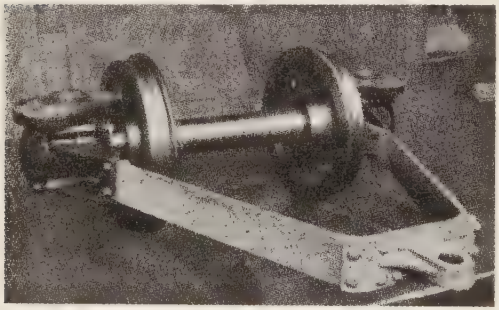


Fig. 15. — Bissel truck wheel set for locomotive referred to in fig. 14.

with any great success because of the difficulties of assembly and dismantling, but in overseas countries their use is comparatively widespread.

As regards the dimensions to be given to bearings, and consequently to the axleboxes, nothing has been published so far.

On account of the uncertainty of the hypotheses on which the theoretical determination of bearing dimensions is based, it would appear advisable to base the investigations on the practical experiments, which is now possible since large quantities of roller bearings have been in service over comparatively long periods.

With the assistance of practical results, therefore, the relations which exist between the dimensions of the bearings and their length of life can be determined.

As an example, figure 16 shews curves for selecting the dimensions of axleboxes with two oscillating-roller bearings :

Scale 1 deals with radial axles.

Scale 2 deals with bogies with suspension springs, or with light equaliser springs.

Scale 3 concerns bogies with heavy equalisers or lattice beams.

Scale 4 is for cast steel bogies with rigidly mounted axleboxes.

These curves give the necessary dimensions for any given life required, in millions of kilometres, with a specified type of mounting. Diagrams of the same type may be drawn up for boxes with a single bearing. It is necessary to make a distinction between the different types of mounting seeing that, for lattice bogies for example, or for heavy bogies with cast frames, account must be taken of the unsprung weight, which is relatively considerable. Also, it is necessary

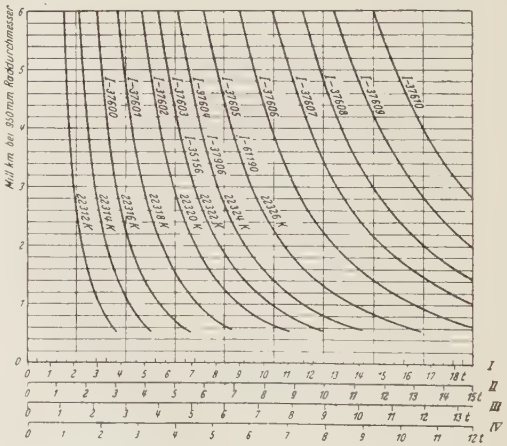



Fig. 16. — Diagram for selecting the dimensions of axleboxes with two oscillating-roller bearings (for passenger and goods vehicles and railcars).

to distinguish between goods wagons, passenger vehicles and railcars on the one hand, and locomotives and tenders on the other.

It may be mentioned again in this connection that various experimental types of roller bearings are also used for connecting and coupling rods of steam locomotives, and that, in spite of the very difficult working conditions, the tests so far made permit favourable results to be anticipated.

Thus, in 1933, an American main-line locomotive was fitted with roller bearings, for trial purposes, on the connecting rod ends. In the same way, in France and South Africa, certain experimental locomotives were equipped with roller bearings on all rod ends. Figure 17 shews the driving crank pin of a 4-6-2 locomotive for service in the U. S. A. The diameter of the pin is 200 mm. (7 7/8") and the bearing comprises two oscillating-roller sets with seating collars.

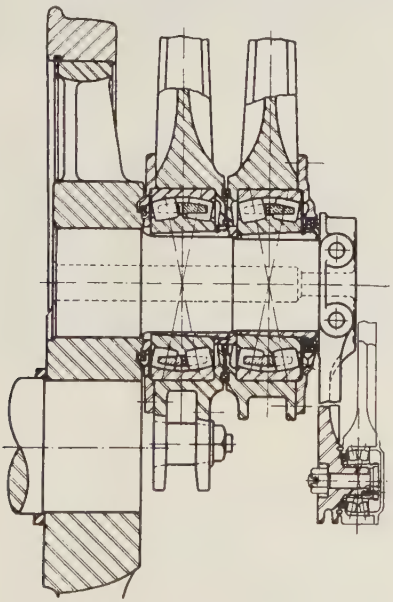


Fig. 17. — Driving crankpin roller bearings for 4-6-2 express locomotive (Delaware and Hudson Railroad, U. S. A.).

The Reichsbahn is now testing roller bearings on the driving crank pins and on the coupling rod crank pins of a 01 series locomotive, type 2C1 (4-6-2) (6).

The reason why the use of roller bearings for rail vehicles has been extended fairly widely may be sought amongst the properties already quoted; security of operation, maintenance and lubrication demanding little attention; the saving in energy might also be mentioned. The importance of this latter point, however, is controversial, and not definitely known; at the same time, it can be held for certain that, all things being equal, roller bearings do allow a great energy saving when starting. Trials carried out at various points have shewn proportions of from 1:4 to 1:8 for different wagon loads and capacities. In addition, proof is clearly given that the saving in energy is comparatively large at low speeds and decreases progressively as the speed rises, because of the double fact that when the rate of revolution is constant, and fairly moderate, roller bearings are working under the most favourable conditions and above all, the air resistance increases with the square of the speed. Further, it can be admitted as approximately accurate that with speeds of about 60 to 80 km. (37 to 50 miles) an hour a saving in tractive effort of 8 to 10 % is realised; this decreases at higher speeds.

(6) See Dr.-Ing. HOLTMEYER, Reichsbahnrat : « Lager und Schmierungsfragen bei Reichsbahnlokomotiven » (Bearing and lubrication problems on the locomotives of the Reichsbahn). *Organ für die Fortschritte des Eisenbahnwesens*, No. 19, 1937.

[ 621. 132.5 (.73) ]

# New York Central 4-6-4 locomotives show high power concentration.

(From *Railway Age.*)

Fig. 1.

Ten streamline steam locomotives of the 4-6-4 type are now being delivered to the New York Central by the American Locomotive Company. These locomotives are the last to be delivered of an order of 50 of the J-3a class, the exterior finish of the first 40 of which is of conventional character. The 40 non-streamline locomotives were delivered during the latter part of 1937 and some of them have already run approximately 100 000 miles in service.

The J-3a class locomotives mark a distinct advance both in proportions and in certain details of mechanical design from the earlier J-1 class 4-6-4 type locomotives, the first of which were delivered to the New York Central by the same builder in 1927. The boiler proportions have been materially changed by the insertion of a 43-in. combustion chamber, and by reducing the length of the smokebox to permit moving the tube sheet 25 in. forward. The length over the tube sheets has been reduced by 18 in. to 19 ft. The boiler pressure has been increased from 225 lb. to 275 lb. per sq. in.

These modifications have effected a considerable change in the distribution of heating surface and have effected an increase in boiler capacity of approximately 10 per cent with an accompanying increase in boiler efficiency of about the same amount. By the use of alloy steel in the boiler shell courses and care in the design of details throughout the locomotive the total weight of the engine has been increased only 0.4 per cent, while the weight on drivers has been increased approximately 3 per cent, as compared with the most recent J-1 design. The drawbar horsepower and fuel efficiency characteristics are shown graphically in figures 11 and 12.

In dynamometer tests the new J-3a lo-

comotives have developed a maximum indicated horsepower of 4 700 at 80 m. p. h. and a maximum drawbar horsepower of 3 880 at 65 m. p. h. The J-1 locomotives in a number of tests developed a maximum indicated horsepower of 3 950 at 65 m. p. h. and a maximum

Fig. 2.

drawbar horsepower of 3 200 at 57 1/2 m. p. h., an increase in maximum drawbar capacity of 21 per cent. At medium-capacity performance, burning 5 500 lb. of dry coal, tests of the new locomotives show an equivalent evaporation of 63 000 lb. per hour, which compares with an equivalent evaporation of 57 500 lb. per hour for the J-1 locomotives at the same coal rate. This is an increase from an equivalent evaporation of 10.5 lb. per pound of dry coal to 11.5 lb. per pound of dry coal, or 9.6 per cent. At the high combustion rate of 8 250 lb. of dry coal per hour the new locomotives produce an equivalent evaporation of 89 000 lb. as compared with 81 000 lb. for the earlier class. This is an increase in equivalent evaporation per pound of dry coal from 9.9 to 10.8, or 9.1 per cent. Although the boilers of the new locomotives have less superheating surface than those of the earlier class, largely because of the shorter tubes, they consistently show 30 and 40° F. higher superheat at medium and high rates of boiler output, respectively.

In the range of average dynamometer horsepower (from 2 000 to 2 300) the new locomotives develop a drawbar horsepower with from 3.4 lb. of dry coal at 2 000 H.P. to 3.25 lb. of dry coal at 2 300 H.P. The locomotives of the earlier design showed approximately a flat dry coal rate of 4 lb. throughout this horsepower range.

### The boiler.

With the insertion of the combustion chamber the form of the boiler has been slightly changed from the straight-top type employed in the J-1 locomotives. The inside diameter of the first course has been reduced 1 13/16 in. to 80 5/8 in. The second course is conical. The outside diameter of the third course has been increased 3 7/8 in. to 91 1/2 in. The tube-sheet layout has been modified by the installation of a larger number of 2 1/4 in. tubes without, however, essentially changing the number of units in the Type E superheater. The reduction in the length of the tubes, however, has effected a reduction in the superheating surface. The shell courses, the welt strips and dome liner are of nickel steel. The dome, which is on the conical course, is flanged of carbon steel.

The inside firebox is completely welded. The inside and outside side sheets are welded to the mud ring at the corn-

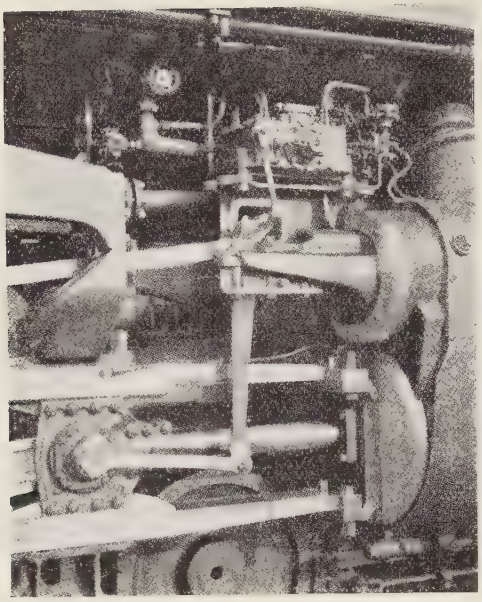


Fig. 3. — Among other details this view shows the Timken crosshead, the lubricator and lubricator drive.

ers and the outside sheet calking edges at both the throat-sheet and back-head seams are welded above the sixth row of staybolts from the mud ring.

Both the front-tube sheet and the back-head bracing are in the form of gussets, except for three points on the tube sheet and two points on the back head where clearances made necessary

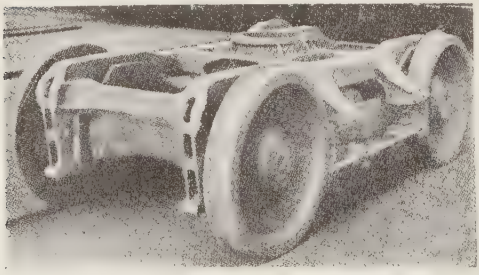


Fig. 4. — The engine truck.

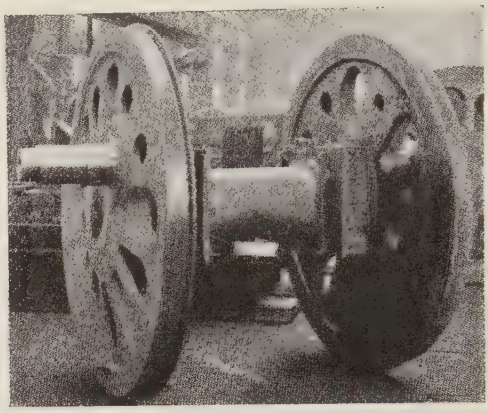


Fig. 5. — Main driving wheels of the locomotives with conventional rods.

the use of rods. The back-head gussets are flanged and riveted directly to the wrapper sheet. The tube-sheet gussets are attached by angles to both the shell and the tube sheet itself.

The fireboxes have extensive installations of F. B. C. telltale type flexible stays. These include all crown stays, except the middle six rows, and the entire back head, throat sheet and side sheets, except for the bottom row next

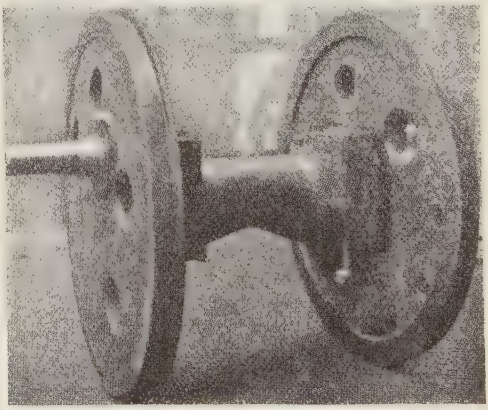


Fig. 6. — Main driving wheels of the locomotives fitted with Timken roller-bearing rods.

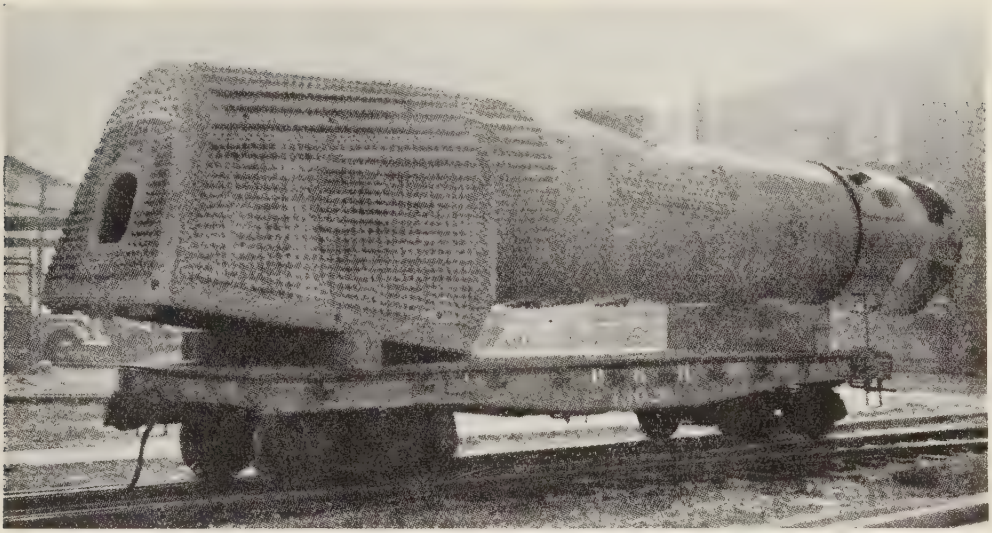


Fig. 7. — The boiler for the J-3a class 4-6-4 type locomotives.

to the mud ring. There are four combustion tubes through each side of the firebox, each so located as to be opposite a staybolt on the other side of the firebox.

The brick arch is mounted on four arch tubes. The grates are of the Firebar type and coal is fed by a type H-T Standard stoker. The stoker engine is mounted at the rear end of the locomotive.

The locomotive is equipped with the Elesco type K40 feedwater heater which is mounted within the top of the smokebox in front of the stack. Recesses within the smokebox shell are provided for feedwater-heater pipe connections. The spark arrester is of the box type, enclosed with Draftac netting on the top and sides and with a solid bottom at the elevation of the top of the exhaust nozzle.

There are steam separators on the dry pipes on these locomotives, those on half of the locomotives being the Tangential type and those on the other half being of the Dri-Steam type. Barco low-water alarms are fitted on all of the boilers. The American multiple throttle is built into the superheater head.

**Engine bed and running gear.**

The foundation of the locomotive is the General Steel Castings engine bed. Cast integral with the bed are the cylinders and back cylinder heads, the brackets for the air compressors, the guide yoke, the valve-gear-frame crosstie, pads for the driver-brake cylinders and reverse gear, and attachments for the stoker engine and cab brackets. The front bumper beam and the pilot are separate steel castings. The pilot includes a pocket for the counterbalanced disappearing coupler.

The boiler is supported by sliding shoes at the front corners of the mud ring and by expansion plates below the back head. Waist sheets are located at the guide yoke, at the valve-motion support, and between the second and third

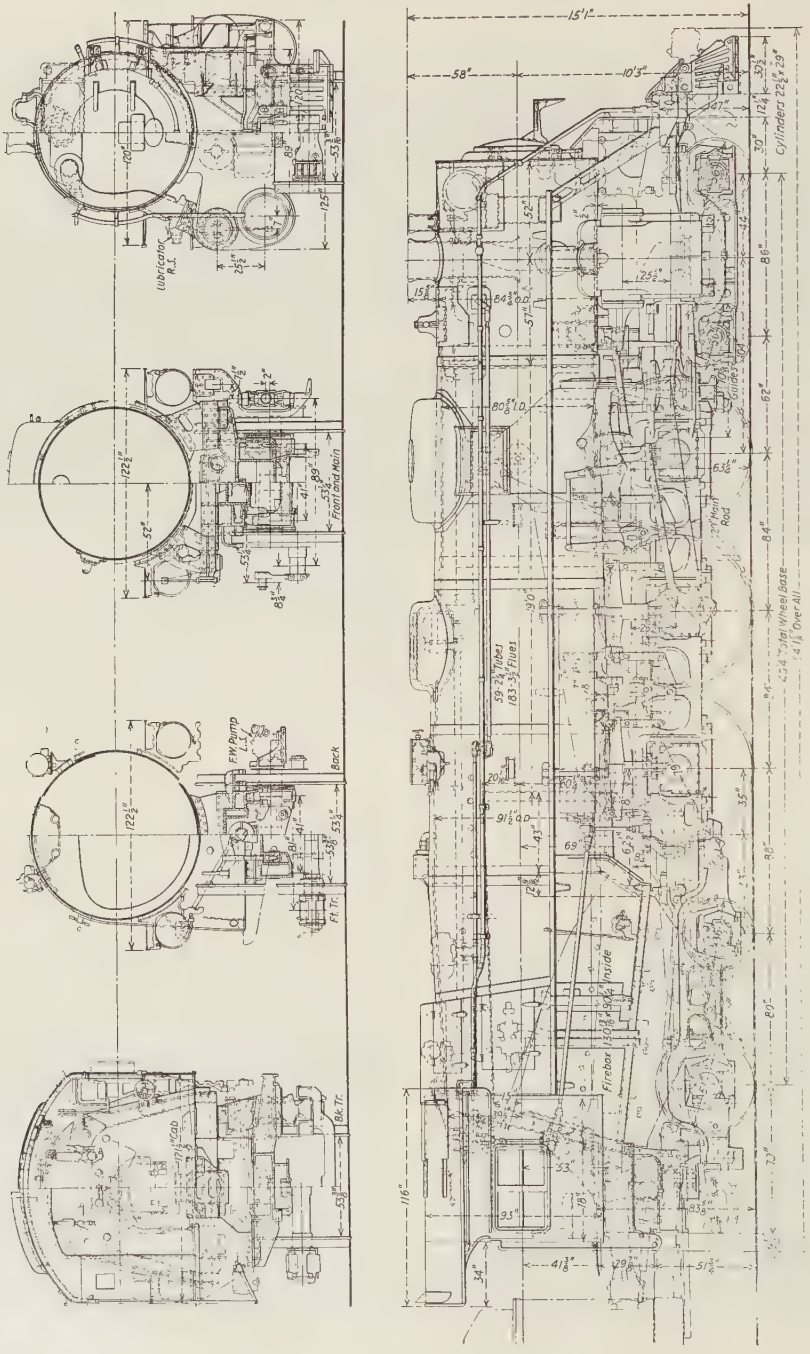



Fig. 8. — Elevation and cross-sections of the New York Central class J-3a 4-6-4 type locomotives.

## General dimensions, weights and proportions of the New York Central 4-6-4 type locomotives.

| | |
|---|---|
| Railroad | New York Cent. |
| Builder | Amer. Loc. Co. |
| Type of locomotive | 4-6-4 |
| Road class | J-3a |
| Date built | 1937 |
| Service | Passenger. |
| Dimensions : | |
| Height to top of stack, ft. and in. | 15-1 |
| Height to center of boiler, ft. and in. | 10-3 |
| Width overall, in. | 125 |
| Cylinder centers, in. | 89 |
| Weights in working order, lb.: | |
| On drivers | 196 000 |
| On front truck | 66 000 |
| On trailing truck | 98 000 |
| Total engine | 360 000 |
| Tender | 314 300 |
| Wheel bases, ft. and in. : | |
| Driving | 14-0 |
| Rigid | 14-0 |
| Engine, total | 40-4 |
| Engine and tender, total | 83-7 1/2 |
| Wheels, diam. outside tires, in.: | |
| Driving | 79 |
| Front truck | 36 |
| Trailing truck | 36 and 51 |
| Engine : | |
| Cylinders, number, diam. and stroke, in. | 2-22 1/2 × 29 |
| Valve gear, type | Baker. |
| Valves, piston type, size, in. | 14 |
| Maximum travel, in. | 8 1/2 |
| Steam lap, in. | 1 5/8 |
| Exhaust clearance, in. | 3/16 |
| Lead, in. | 1/4 |
| Cut-off in full gear, per cent | 85 |
| Booster | Franklin, type C-2. |
| Boiler : | |
| Type | Conic. connect. |
| Steam pressure, lb. per sq. in. | 275 |
| Diam., first ring, inside, in. | 80 5/8 |
| Diameter, largest, outside, in. | 91 1/2 |
| Firebox length, in. | 130 13/16 |
| Firebox width, in. | 90 1/4 |
| Height mud ring to crown sheet, back, in. | 68 |
| Height mud ring to crown sheet, front, in. | 89 1/16 |
| Comb. chamber length, in. | 43 |
| Arch tub., numb. and diam., in. | 4-3 1/2 |
| Tubes, number and diam., in. | 59-2 1/4 |
| Flues, number and diameter. | 183-3 1/2 |
| Length over tube sheets, ft. and in. | 19-0 |
| Net gas area through tubes and flues, sq. ft. | 8.93 |
| Fuel | Bituminous. |
| Stoker | Standard, type H-T. |
| Grate type | Firebar, rocking |
| Grate area, sq. ft. | 82 |
| Heating surfaces, sq. ft. : | |
| Firebox and comb. chamber. | 323 |
| Arch tubes | 37 |
| Firebox, total | 360 |
| Tubes and flues | 3 827 |
| Evaporative, total | 4 187 |
| Superheating | 1 745 |
| Comb. evap. and superheat | 5 932 |
| Feedwater heater, type | Elesco |
| Tender : | |
| Style or type | Rectangular water leg |
| Water capacity, gal. | 14 000 |
| Fuel capacity, short tons. | 30 |
| Trucks | Six-wheel |
| Journals, diam., in. | 5.906 |
| General data, estimated : | |
| Rated tractive force, engine, 85 per cent, lb. | 43 440 |
| Rated tractive force, booster | 12 100 |
| Total rated tractive force, lb. | 55 540 |
| Weight proportions : | |
| Weight on drivers ÷ weight engine, per cent | 54.45 |
| Weight on drivers ÷ tractive force | 4.51 |
| Weight of engine ÷ evaporat. heat. surface. | 85.95 |
| Weight of engine ÷ comb. heat. surface | 60.69 |
| Boiler proportions : | |
| Firebox heat. surface, per cent comb. heat. surface | 6.07 |
| Tube-flue heat. surface, per cent comb. heat. surface | 64.52 |
| Superheat. surface, per cent comb. heat surface | 29.42 |
| Firebox heat. surface ÷ grate area | 4.39 |
| Tube-flue heat. surface ÷ grate area | 46.68 |
| Superheat. surf. ÷ grate area | 21.28 |
| Comb. heat. surface ÷ grate area | 72.38 |
| Gas area, tubes-flues ÷ grate area | 0.109 |
| Evaporat. heat. surface ÷ grate area | 51.06 |
| Tractive force ÷ grate area. | 529.8 |
| Tractive force ÷ evaporat. heat. surface | 10.38 |
| Tractive force ÷ comb. heat. surface | 7.32 |
| Tractive force × diam. drivers ÷ comb. heat. surf. | 578.5 |

Fig. 9. — One of the 40 class J-3a 4-6-4 type passenger locomotives.

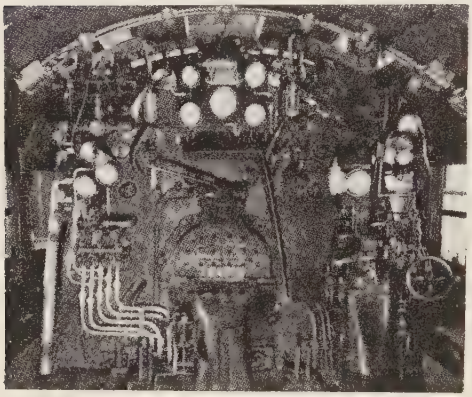


Fig. 10. — Interior of the cab of one of the streamline locomotives.

pairs of drivers. The main reservoirs are of Cor-Ten steel and are mounted in Economy combination reservoir and pipe brackets, supported from the boiler. The running boards are supported on separate brackets attached directly to the boiler shell.

The driving wheels are of the General Steel Castings Boxpok type on 25 locomotives and the Scullin disc type on the remaining 25. They are mounted on normalized carbon-vanadium steel axles, hollow bored to 3 1/2 in. diameter. The driving-journal bearings are fitted with Timken roller bearings in single-piece housings. The pedestal faces in the bed casting are parallel and are provided with cast-steel shoes faced with rolled-bronze liners welded in place. The pedestal caps are of alloy steel. The driving springs have reverse camber with conventional equalization.

The four-wheel engine trucks are of the Commonwealth equalized type with inside journal bearings. The truck frame is of special design to permit the carrying of the brake cylinder under the bolster in a sleeve which is an integral part of the frame. The Timken roller bearings are mounted in one-piece housings.

The trailer trucks are of the Commonwealth four-wheel type with outside journals which are fitted with Timken roller-bearing boxes. The Timken lateral-motion device is applied on the front trailer boxes. A Franklin C-2 type booster is installed on the trailer, the exhaust from which is discharged through the tank to the atmosphere.

The engine truck and front trailer wheels are rolled steel, while the rear trailer wheels have steel-tired cast-steel centers. Engine-truck axles are normalised carbon-vanadium steel, while trailing-truck axles are carbon steel. The rear trailer axle and the engine-truck axles are hollow bored. All Timken bearings are equipped with automatic heat indicators.

**Driving gear and motion work.**

The rods and crank pins on 45 of the locomotives are conventional. On five of the streamline locomotives are complete installations of Timken roller-bearing rods and crank pins. On all of

the locomotives, however, the pistons, piston rods and crossheads, including the wrist pins, are of Timken design and special alloy steel.

By the use of these parts the total weight of reciprocating parts on each side of the locomotives has been reduced to 1 000 lb. and the dynamic augment decreased by about 50 per cent of that of the J-1 class. With an overbalance of

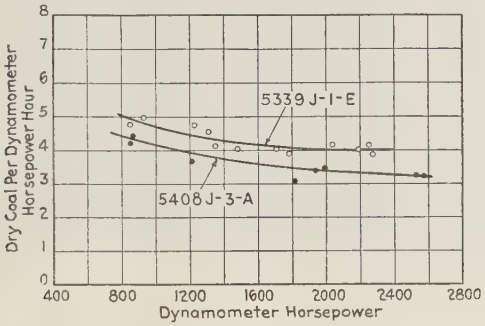



Fig. 11. — A comparison of the dry coal per dynamometer horsepower-hour of the J-1e and J-3a classes of the New York Central.

134 lb. in the front and back driving wheels and 100 lb. in the main driving wheels, the calculated dynamic augment at 90 m. p. h. is 8 100 lb. in each of the front and back wheels and 6 020 lb. in each of the main wheels. The revolving weights are cross-counterbalanced in all wheels.

The guides are of the two-bar type with the Slid-Guide floating connection of the top guide at the cylinder head. The Timken two-piece crosshead, with a draw fit on tapered circumferential shoulders of the piston rod, has forged shoes of aluminum alloy. The crosshead contains a roller-bearing wrist-pin assembly.

The main and side rods on 45 locomotives are of nickel steel. In the back end of the main rod and in the side-rod middle connection are three-piece bronze floating bushings with fixed bushings of Hunt-Spiller gun iron. The front and back side-rod bearings are bronze bushings, pressed in.

On the 45 locomotives with plain crank-pin bearings the main crank pins are of normalized carbon-vanadium steel and the front and back crank pins are normalised and drawn carbon steel. The main pins are hollow bored to a diameter of 4 in.; the others, to 2 1/2 in.

The cylinders and valve chambers are bushed with Hunt-Spiller gun iron. The pistons are fitted with L. F. M. bronze lip and ring cylinder packing, while the valves have Hunt-Spiller gun-iron bull-rings and snap packing rings. King type rod packing is applied on piston rods and valve stems.

All of the locomotives have Baker valve gears and Loco Valve Pilots. On the five streamline locomotives on which the Timken roller-bearing rods are installed Multirol needle bearings have also been applied in the valve motion.

The Franklin Precision type reverse gear is mounted on the engine bed on the longitudinal center line of the locomotive. By the use of spiral gear boxes and universal and spline slip joints the operating shaft is carried from the cab along the side of the firebox to the reverse-gear cylinder under the boiler with with complete flexibility of adjustment to changing length due to the expansion and contraction of the boiler. The boiler mounting of the reverse-gear cylinder is

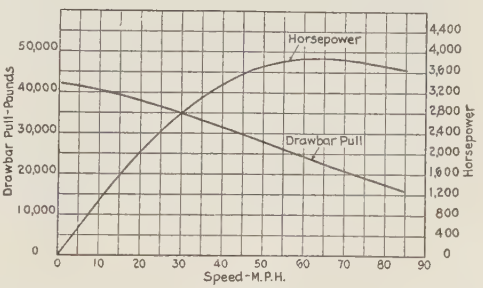



Fig. 12. — Drawbar pull and drawbar-horsepower characteristics of the J-3a class 4-6-4 type locomotives.

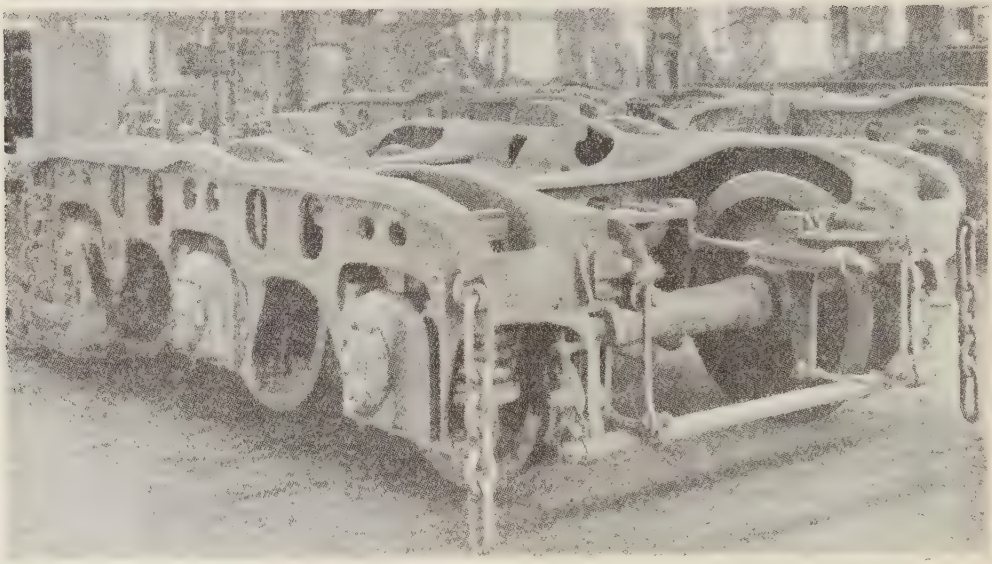


Fig. 13. — The six-wheel tender truck.

particularly difficult to maintain satisfactorily because of the constantly changing thrust reactions to which the boiler studs are subjected when the locomotive is in service. The engine bed provides a better anchorage and relieves the boiler of these stresses. Furthermore the location of the reverse gear on the longitudinal center line of the locomotive, so that the connection to the reverse shaft is at a point midway between the two valve gears, equalizes any distortion of valve events which may be caused by torsional strains in the shaft.

**Lubrication.**

A force-feed lubricator is installed on each of the locomotives. Four feeds lead to the cylinders and valves, two to the guides, one to the air compressors and one to the stoker engine. The Nathan type DV 24-pint lubricator is on half of the order and the Detroit 32-pint lubricator on the other half. The Nathan atomizers are used on all of the locomotives.

Alemite soft-grease fittings are extensively applied. They are used on the valve gear, on the radial buffer, on the reverse gear, on the main and side rods, on the valve-stem crossheads, on the trailer spring-hanger pins, on the water-scoop piston rod, and on such auxilia-

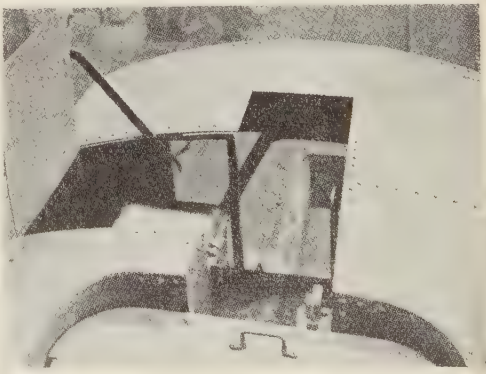


Fig. 14. — Hatchway leading from the rear of the tank to the filling-hole cover on the streamline locomotives. — The trap door opens over the train-control equipment.

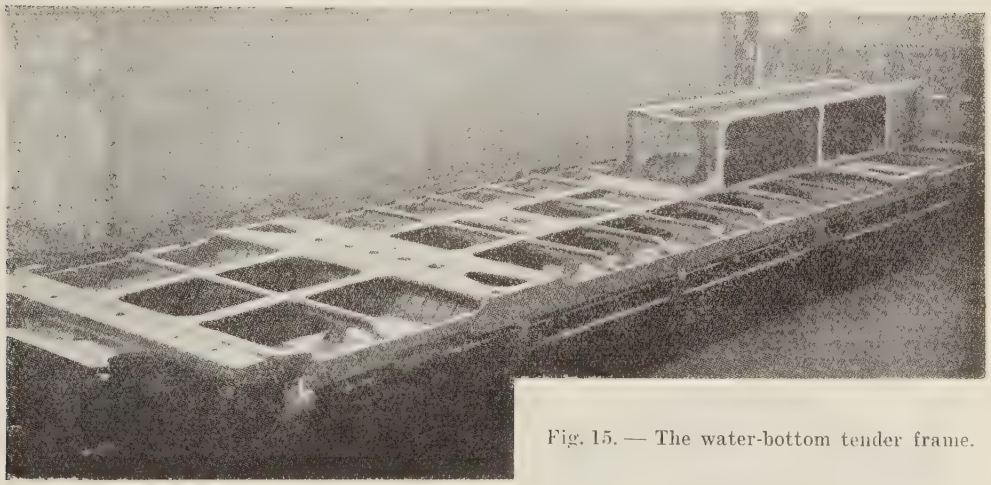


Fig. 15. — The water-bottom tender frame.

ries as the Elesco feedwater pump and the speed recorder connections.

On all of the locomotives equipped with plain-bearing rods and crank pins there are air connections for use with a portable pneumatic grease gun with which the rods are lubricated.

**The cab.**

Aluminum alloy has been used extensively on these locomotives. The cabs and running boards of all but 10 of the non-streamline locomotives were built of this material, while Cor-Ten steel was used in the construction of the cabs and running boards of the remaining locomotives. The cabs and running boards of the 10 streamline locomotives are also of aluminum alloy, as are the cylinder and valve-chamber casings on all locomotives. The hand rails are of aluminum pipe. Aluminum is also used for the dome casing, safety-valve and steam-turret casings, and cab gage board.

The No. 8ET brake equipment was furnished by the New York Air Brake Company. The brake is modified to include the electro-pneumatic and speed-governor control for use with cars equipped with the H. S. C. type brakes. The brake valve is pedestal mounted.

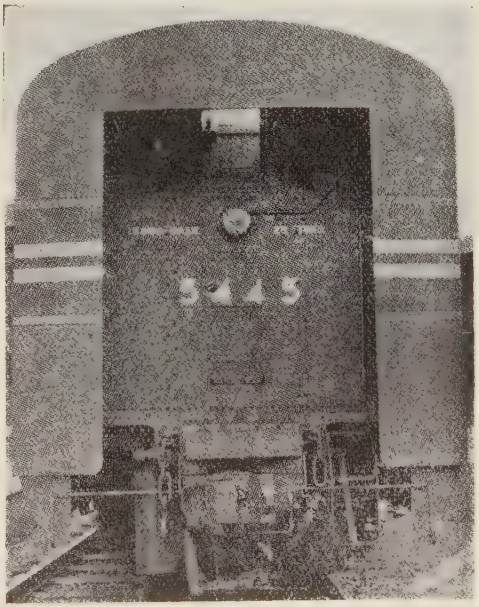


Fig. 16. — Rear of the streamline tender.

Brake shoes are applied on the engine truck and the rear pair of trailer wheels as well as on the drivers. The braking ratio on the drivers and engine truck is 60 per cent and on the trailer 45 per cent.

The locomotives are fitted with the General Railway Signal train control. Graham-White sanders are applied. The sand capacity is 27 cu. ft.

**The streamline locomotive.**

The streamline locomotives are finished to the design of Henry Dreyfuss, offer

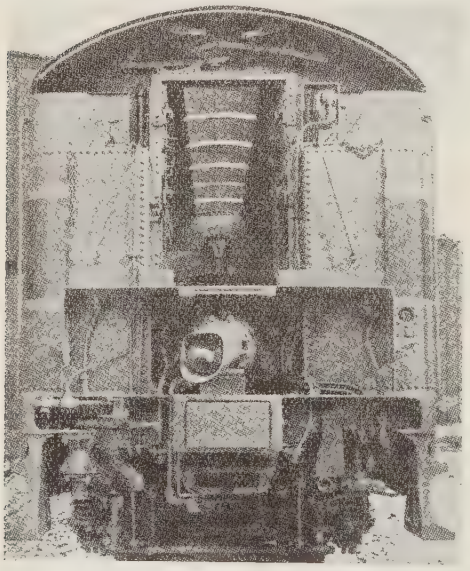


Fig. 17. — The front of the tender of one of the streamline locomotives, showing the mechanism for operating the hinged hatches over the coal space.

relatively little interference to access to running gear and motion work, and weigh only 5 500 lb. more than the conventional design. The streamlining consists of the lagging and jacketing of the smokebox with a bullet nose type of covering over the front end and a housing over the top of the boiler extending forward from the cab to include the smoke stack, with air openings at the front for smoke-lifting purposes. The headlight is located at the middle of an aluminum crest which follows the contour of the bullet nose along the vertical center line of the locomotive from the housing which covers the top of the boiler to the shrouding which covers the space under the smokebox. This shrouding also covers the pilot. At the sides it extends only as far as the steps from the bumper beam to the running board. Below the running board, beginning at a point approximately half way back, is an apron which conforms roughly to the line of the throat sheet and mud ring and extends back to the rear of the cab.

A housing which covers the sides of the tender coal space conforms to the curve of the cab roof. An inward-curving skirt is dropped below each side of the tender approximately to the centers of the tender truck wheels.

Above the running boards the boiler jacket, shrouding and cab are finished in light grey Duco. The underneath parts, including the frames, trucks and other parts are finished in a darker tone of grey with aluminum finish on the driving wheels. The front cylinder head and valve-chamber casings are in the natural aluminum color. The main and side rods, as well as the valve-motion rods, are polished. Lettering and the striping on the tender are in aluminum. There are two longitudinal stripes in blue on the sides of the tender, one above and one below the aluminum striping and lettering. The background of the emblem on the front shrouding is also in blue.

There are relatively few changes in the location of equipment about the locomotive as the result of the streamlining. The turbo-generator has been moved from the top of the boiler to a bracket on the engine bed just ahead of the trailer truck on the right side, opposite the location of the feedwater pump. The

bell has also been removed from the top of the boiler and placed under the pilot.

### The tender.

The tender tank is built up on a Commonwealth water-bottom cast-steel underframe. The water capacity is 14 000 gallons and the large coal space carries 30 tons. A coal pusher is installed.

The tender trucks are of the Commonwealth six-wheel type with rolled-steel wheels. The tender axles are fitted with SKF roller-bearing boxes. Clasp brakes are applied on the trucks, with body-mounted cylinders.

All air and steam lines have Barco flexible connections between the engine and tender. The Vapor flexible metallic steam-heat connection is applied at the rear end of the tender. The tender drawbar is equipped with the Waugh rubber draft gear. The streamline locomotive tenders are equipped with A. A. R. tight-lock couplers furnished by the National Malleable and Steel Castings Company.

The principal dimensions, weights and proportions are shown in the table.

[ 656. 257 (.44) ]

# The power boxes of the French Est Railways (*).

***Features of the Descubes type route tables and Vinot semi-automatic locally controlled power frames, as described in a paper read at the "Association Française des Amis des Chemins de Fer",***

by Mr. LECOMTE,

Assistant track engineer of the Est Railways.

(*Bulletin de l'Association Française des Amis des Chemins de Fer.*)

### How the power boxes were developed.

It is common knowledge that safety of train operation does not depend only on a very clear signalling system ensuring faultless protection of the trains, but also on the perfect operation of the track apparatus situated on, or giving access to, the running roads.

It is essential, in fact, that it should only be possible to operate these track apparatus, as well as its protecting signals, if no dangerous condition is created by so doing. It is therefore necessary to lock by technical methods the levers (or similar devices) operating the points and signals in the position offering every guarantee of safety in train running. This is accomplished by what is called interlocking, which may be divided in two categories :

1. The so-called lever interlocking, by which it is impossible for a signal giving access to a given section to display the « line clear » indication, unless the points in the route in question are set and locked in the proper position, and unless the points and signals giving access to the route considered are locked and set to avoid conflicting movements.

2. Route or traffic locking, which allows for the circulation of trains, and the object of which is to either lock or release certain apparatus when a given section is being occupied or when the train passes a certain point under predetermined conditions.

At the beginning the track apparatus used to be relatively light. There used to be only a small number of such devices even in important stations.

So far as the signals were concerned, they were all of the disc or semaphore type.

Both the points and signals were located in the vicinity of the operating de-

(*) Now « Eastern Area » of the *French National Railways Company.*

vices which were of the mechanical type, and controlled by means of wires or rodding.

The track apparatus became gradually heavier. Stations were considerably increased in area and number of points. In consequence, the length of the transmission wires and rods was continually increased, until in certain places the physical impossibility of the signalmen to cope with the situation necessitated an immediate remedy .

This consisted in the erection of power boxes, i. e. those boxes from which all the points and signals are operated by such means as water under pressure, compressed air, or electrical energy. Hydraulic, pneumatic and hydro-pneumatic devices have also rendered great services; a large number of these boxes are still operating successfully.

However, of all the various methods used, electric operation has progressed furthest. It is at the same time the most adaptable power, since it is the easiest to install, and modifications are relatively simple. It is also the power least affected by atmospheric variations (extreme climatic conditions, subsiding of the ground, etc.). Finally, it is the electrical apparatus that offers the most technical possibilities.

These are the reasons why all the power boxes installed on the Est Railway lines are boxes from which the points and signals are operated by means of electricity to the exclusion of any other means, and thus they belong to the kind of boxes generally known as « electric power boxes ».

The principal features of such power boxes are :

1. Operation proper and control of each track apparatus.

2. Operation proper and control of each signal.

3. Grouping of controls for the whole of the track apparatus and signals in one or more interlocking frames whose levers (or similar devices) are locked in the position offering every guarantee of safety to running trains.

### Electrical operation and control of points (fig. 1).

The points are operated by means of electric motors actuating the stretcher rod. The majority of motors are for D.C. operation and are series wound. They comprise :

— either double field — one for the operation of the points in one direction and the other for the operation in the opposite direction;

— or a single field, the direction being changed by reversing the current in the armature.

The motors lock the points and are equipped with electrical contacts making it possible to control the locking of the points in their open and home positions.

If it is a case of facing points for high-speed traffic, these points are operated as follows :

— either by means of motors that lock them through a locking device in the motor itself, which locking device is equipped with electrical contacts designed to control in each extreme position that this locking device is properly set;

— or by means of independent point locks which lock the closed tongues directly with more than adequate strength, and which are provided with electrical contacts in order to obtain a control that the locking is effective.

The 110-volt operating circuit of the point machines is closed by relays fed at 24-volts. The relay governing the movement of the points for the left-hand direction and that governing the movement of the points for the right-hand direction are combined in one single device called « servo-relay », or point contactor relay. It is thereby possible to interlock their armatures mechanically

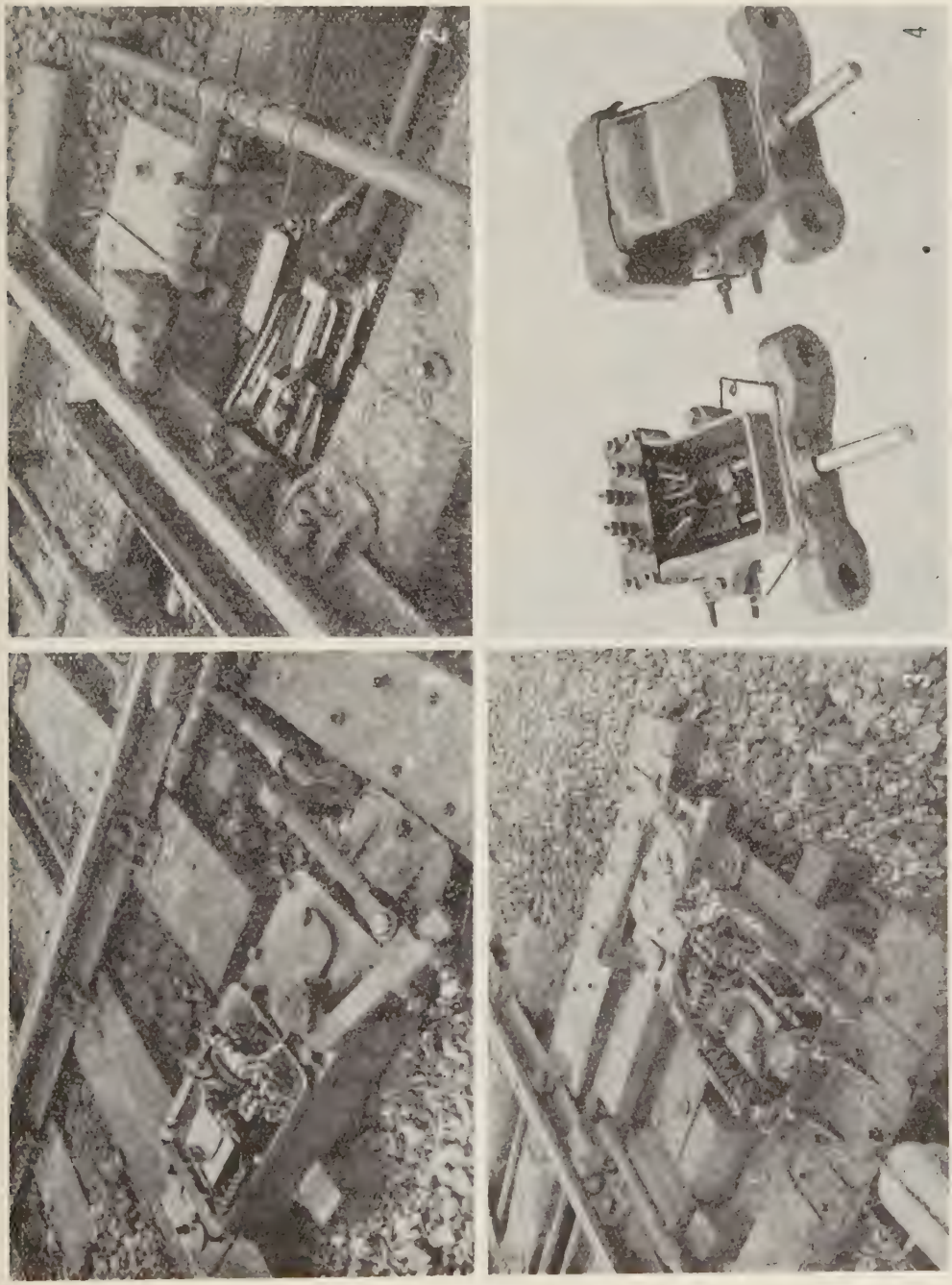


Fig. 1. — ES type point motor; 2. Aster type lock; 3. HS type point motor; 4. Mars type point detector.

so as to avoid the points being operated for the left-hand direction and the reverse direction simultaneously.

A check is made that the point tongues are in the position corresponding to that of the motor. This is accomplished by a point detector in which a rod operated by the point tongue moves a carriage bearing a set of insulating fingers making or breaking the contacts which determine the position of the points.

The control of a pair of points is thus obtained in the power box, or cabin, from two relays, as follows :

One of these relays, called normal control relay, is energized by a circuit in series with the following (1) :

1. the motor locking control contacts in the normal position;

2. where necessary, the contacts of the locking control of the motor in the normal position or of the lock corresponding to this normal position;

3. the contacts of the point detector in the normal position.

The other relay, called reversed control relay, is energized in a similar manner by a circuit taking the following in series :

1. The motor control contacts in the reversed position;

2. Where necessary, the contacts of the locking control of the motor in the reversed position or of the lock corresponding to this reversed position;

3. The contacts of the point detector in the reversed position.

**Electrical operation and control of signals** (fig. 2).

As regards the signals, two cases must be considered :

*(a)* Where so-called mechanical signals are used — mechanical because cause either a disc (« cocarde »), which is opened or closed, or a movable semaphore arm is operated through a D. C. series motor, comprising an electric motor and an electro-magnet.

It is the electrical motor which, through a system similar to a differential pulley, determines the opening of the disc or the dropping of the semaphore arm.

The disc in the « line clear » position or inclined semaphore arm automatically cuts the circuit of the electric motor, which is thus cut out. If the current is then cut in the electro-magnet, the disc or semaphore arm returns to its normal position.

The electric motor circuit is closed by the mercury contact of a relay which is energized by the signal operating device (lever or handle), whereas the electro-magnet circuit, which is closed as soon as the lever is placed in the operating position, is maintained energized as long as the lever is kept in the said position.

*(b)* Where colour light signal panels are used, consisting of metal backgrounds on which are mounted light units, the colour displayed is, usually, by day and by night that which a mechanical signal would display by night under similar track conditions .

In each colour light signal panel, therefore, may be grouped the indications of various mechanical signals, although only those indications are displayed that are of value to the engine driver when approaching the signal panel.

As the signal lights must be seen from a considerable distance, even in bright sunlight, they are displayed by light units whose main components are an electric lamp and a very efficient optical system.

Where a greater spread of the beam is required special arrangements are made, as follows :

— either horizontally (signals used on sharp curves);

(1) The reader is reminded here that one of the point positions is called « normal » and the other « reverse », the signs I+ representing the normal position, and I— the reversed position of the same points.

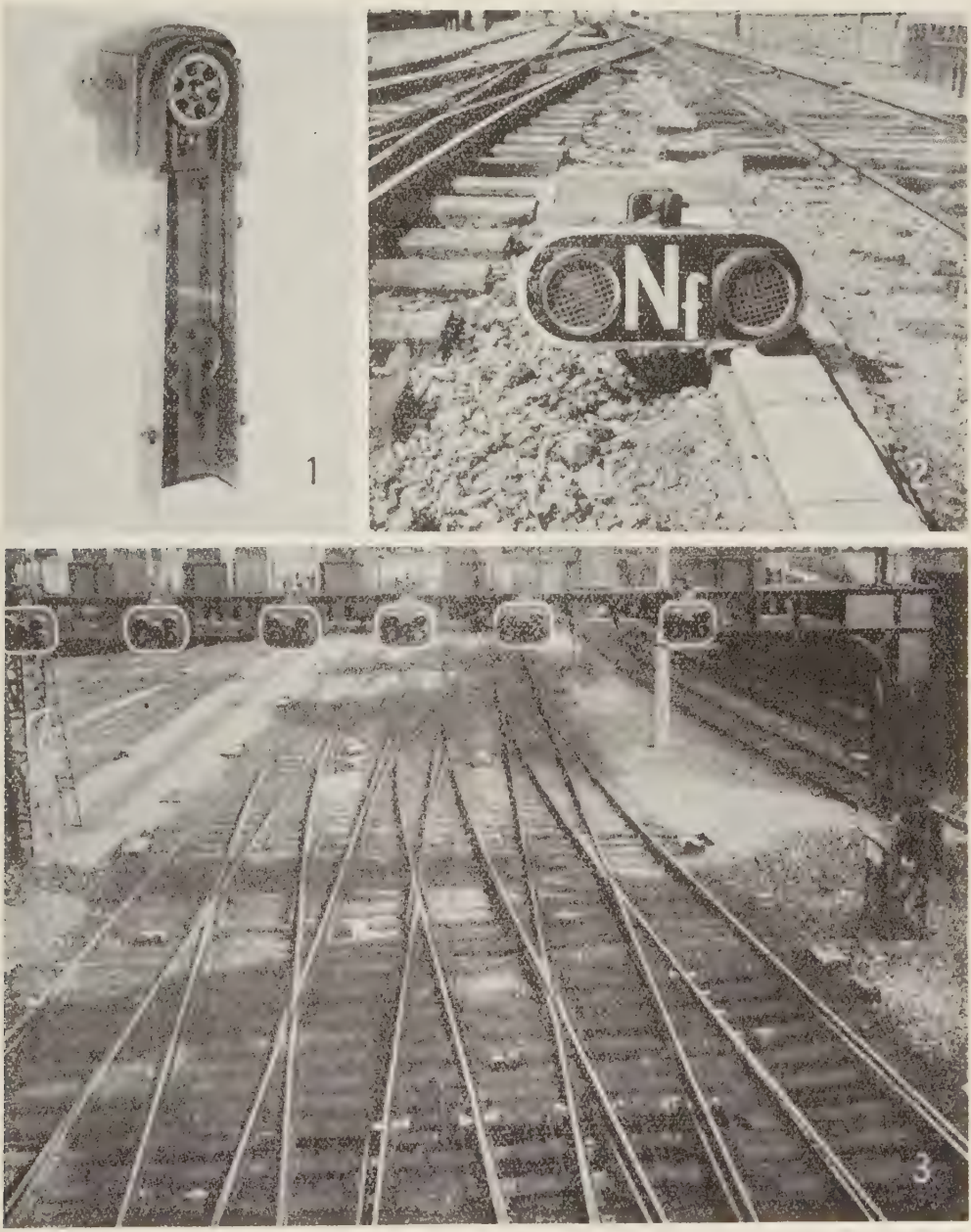



Fig. 2.
1. Est type signal motor; 2. Dwarf signal; 3. Gantry-mounted colour light signals.

— or vertically, either downwards for colour light signals mounted on signal posts, gantries and bridges, or upwards for signals mounted in the six-foot.

The signal indications are obtained by means of special relays called control relays, or « lighting relays », one for each indication, with the exception of the « line clear » indication which is given by the simultaneous energization of all the lighting relays of the panel.

An indication is displayed by the de-energization of the corresponding lighting relay; however, if several of these relays are energized simultaneously, only the most imperative indication is shown, except in very special cases.

Whether mechanical or daylight signalling is used, the « stop » signal (signal carré) indication is controlled from the signalman's cabin. For this a control relay located in the cabin is energized by a special circuit, as follows :

— either by a switch contact made when the arm of the « stop » signal is actually perpendicular to the track (stop indication);

— or by a contact made by the dropping of the control relay corresponding to the « stop » signal indication;

— or by a contact made in the energized position of a special relay called « red indication relay », inserted in the feed circuit of the lights.

### The track circuit.

We will recall briefly what is understood under the name of an insulated rail « or track circuit ».

The track circuit is an electric circuit using the two rails of a track as conductors. The section to be controlled is limited by insulated joints and fed by a battery through a fixed or adjustable resistance.

When there is no vehicle in the section, the energy passes through a receiver (relay) with sufficient intensity to energize it. The presence of a pair of wheels in the section must shunt the receiver, that is, divert a portion of the energy so that the armature of the receiver is no longer attracted. In each of these two positions the armature makes a certain number of electric contacts.

If the resistance is adjustable, it is adjusted in such a manner that the potential difference at the track relay terminals is equal to a predetermined figure.

The Est type track relay includes an electrical mechanism that determines the alternate rotation of a cam made of insulating material, carrying straight silver fingers. These are consequently moved when the position of the armature is changed and in each of the two extreme positions of this armature (minimum and maximum air gap), they make contact with the curved ends of the silver laminations arranged in star formation around the axis of the electrical mechanism. Thus two contacts are made in the maximum air gap position and six contacts in the minimum air gap position.

In the Thomson type track relay, whose characteristics agree with the new standard specification of the French main-line railways, a movable armature makes two contacts in its minimum air gap position and one in its maximum air gap position.

The two minimum air gap position contacts are made between a fixed silver-carbon roundel and a silver finger which moves at the same time as the armature.

The maximum air gap position contact is made between two silver fingers resting on two roundels of pure silver.

### General features of power boxes.

We have seen above how the problem of electrical operation and control of signals and points has been solved by the Est Railways. We shall now exa-

mine how these controls have been concentrated in the power boxes.

There are two types of control frames : those with individual controls and those with route controls.

The former include in principle a lever for each function to be operated : points or signal. In order to set up a route that the train must follow, the signalman proceeds as though he were in an entirely mechanical cabin, that is, one by one he operates the levers affecting the points included in the route. He then operates the lever that clears the entering signal to the route in question.

It is easy to imagine the large numbers of levers that often have to be moved in a cabin with individual controls in a large station, when setting up a route for a train, and it is not surprising if it takes the signalman considerable time to carry out the various movements, and if errors frequently occur due to these many movements.

These successive point and signal lever movements were indispensable, of course, when the signalman had to make a real physical effort to operate, by means of wires or rodding, apparatus offering such resistance that it was often extremely difficult to move. But is it not logical that in those cabins where the operation of levers caused no physical fatigue, all the points included in one route should be operated simultaneously ?

This is the reason why frames working on the route principle came into use at the beginning of this century and rapidly developed.

To begin with, a lever was assigned for each possible route. This seemed to be the simplest, most rational and most practical solution, and so it was adopted by the majority of French makers.

Its undeniable advantage lay in the fact that it reduced to one unit the number of levers to be operated to set the route. There was, however, one very great disadvantage : that of having to use frames with oftentimes a large total number of levers.

Assuming, for example, a section with 30 roads at one end and 6 roads at the other end, all these roads being interconnected, we find that to control such a section with a frame having one individual lever per route, $30 \times 6 = 180$ levers would have to be provided in such a frame to set up the 180 possible routes.

It is true that certain arrangements, such as the splitting up of routes, have made it possible in some cases to reduce the number of levers. Nevertheless, the frames using one lever per route are usually very cumbersome. Furthermore, they seldom lend themselves to such an arrangement of the levers as will allow the signalman to always act with the maximum speed, without hesitation.

**Principles of the Descubes system.**

It was with a view to reducing the size of the control frames and the risk of the signalman making errors in the selection of the levers that Mr. Descubes designed a very ingenious system, the characteristics of which are :

The route to be followed by a train is usually determined when its origin and destination are known.

In such a system, the frame consequently includes as many levers as there are roads by which a train may enter or leave the area governed by the cabin.

Using the previous example, this number of levers would therefore be $30 + 6 = 36$ to set up the 180 possible routes. Obviously, a 36-lever frame is less cumbersome than a 180 lever one, and it is easier to select between 36 levers than between 180.

In addition, are not the risks of mistakes lessened by the fact that the movements of the signalman are purely and simply the carrying out of an order received to direct the train proceeding from an entrance road onto a destination road ?

Still using the previous example, it should be noted that the addition of a road to the 6 roads at one end, and the addition of a connection between this new road and the 30 roads at the opposite end only entails, in principle, the addition of a single lever in a Descubes frame, whereas 30 additional levers would be required in a frame of the one lever per route principle.

It will be observed that an end road may serve as an exit or entrance road, depending on the direction of the train movement. This is exactly the reason why in a Descubes frame each lever may serve both for trains entering or leaving the section by the road governed by that lever.

To this effect, each lever occupies a position called « neutral position », or « zero position », in which it is maintained as long as its road is not being used for any train movement.

When this lever is to be employed as an entrance (origin) lever, it is moved in a certain direction; when used as a leaving (destination) lever, it is moved in the opposite direction.

It is the entrance lever that determines the clearing of the signal permitting the entrance of the train into the route. On this account, when setting up a route this lever is the last to be operated; when cancelling the route it is the first.

**The electro-mechanical control frame.**

The first two frames of the Descubes system were installed in 1909, at Nancy. They were of the mechanical combinator type with electrical controls.

For each pair of points there was a device called « point lock », consisting of a pinion engaging two horizontal racks. These were affixed to two « point rods » sliding along their axis and so interconnected that, if through the movement of a central point rod the pinion axis was displaced horizontally parallel to the point rods, one or the other of these rods — but not both at once — moved in the same direction.

The point rods carried point control contacts or studs at their extreme ends. These did not make any contact when the corresponding point lock was in the normal position, i. e. when it was not used for setting up a route.

To simplify the system all the point rods that were moved simultaneously in the setting up of all the routes affecting them were put in correspondence. On the other hand, through their end contacts the point rods controlled not only the motors of the points which had to ensure the continuity of a route, but also the motors of the points which had to guarantee the safety of this route. Combinations could thus be arranged among those points that were all to be always in the same position (1).

**The all-electric locking frame** (fig. 3).

The two locking frames at Nancy were in use from 1909 to 1936, which shows that electro-mechanical frames were able to give excellent service. But they did not lend themselves to those modifications that are sometimes necessary in control frames located in large interlocking cabins when the track layout in the area governed undergoes alterations, even though they may be of minor importance.

Mr. DESCUBES encountered these difficulties already in 1910, which caused him to improve his system by making it all-electrical. This modified and much more flexible system had the advantage at the same time of allowing a rational classification of the levers. It was possible, in fact, to arrange them in the geographical order of the tracks, in two rows, the lower row corresponding to the tracks situated on the station side,

(1) For details of principle and practice of electro-mechanical and all-mechanical control frames, see *Revue Générale des Chemins de fer*, November 1st, 1936, issue.

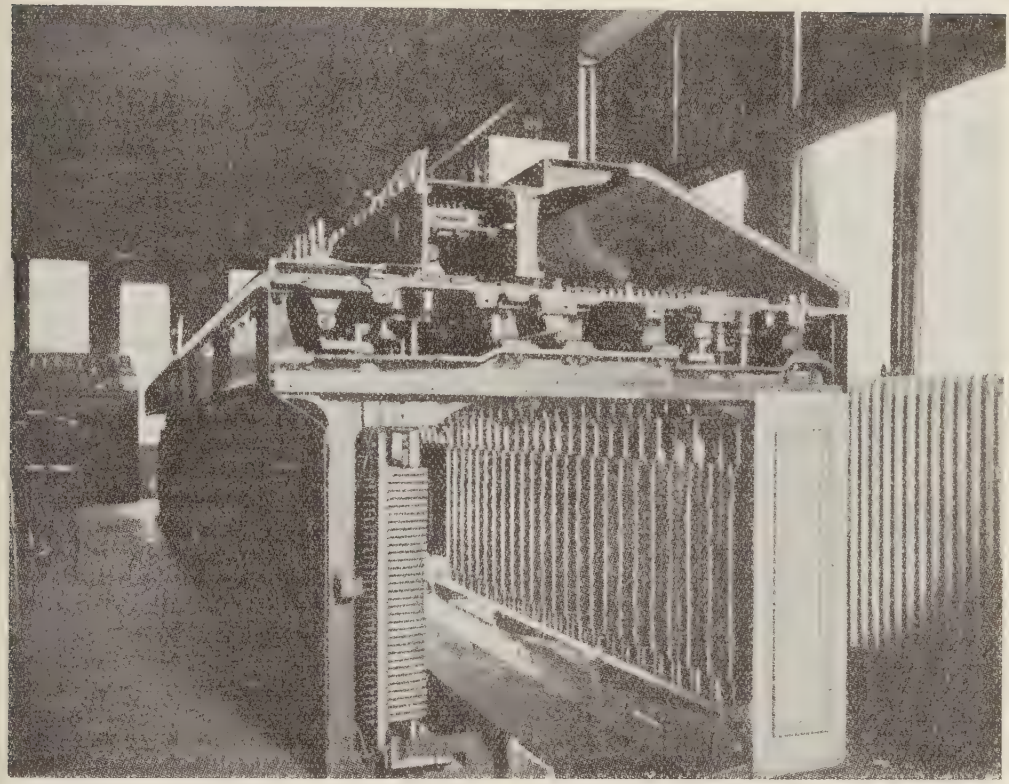


Fig. 3. — Descubes locking frame with all-electric interlocking.

and the upper group corresponding to the tracks situated on the opposite side.

This new lever arrangement rendered the operation by the signalman considerably easier since it permitted a simpler code for setting up and cancelling the routes.

It was decided that to set up an « entering » route the signalman would « pull » towards himself the two end levers of this route, beginning with the « destination » lever, that is with the lever in the lower row, and that to set up a « leaving » route he would « push » the two end levers of this route, beginning with the « destination » lever, that is the lever of the upper row.

Each one of these levers operates the following by means of pinions and racks :

1. A horizontal rod called « interlocking rod » which carries out the mechanical interlocking between the other levers of the table.

2. A notched disc that turns in front of a lock dog moved by an electro-magnet and which electrically interlocks with the other levers.

3. A shaft on which are mounted 33 cams of insulating material whose contact studs open or close (depending on the position of the lever) the electrical circuits governing the setting up, the operation and the control of the route.

Each lever may occupy 7 positions, namely (fig. 4) :

— a vertical position, 0, or neutral position;

— an extreme position, 3, or leaving lever position;

— another extreme position 6, or entering lever position (setting the signal at « line clear »);

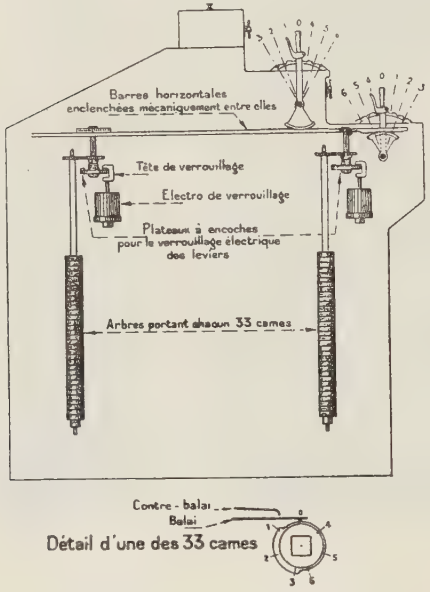

Barres horizontales enclenchées mécaniquement entre elles
Tête de verrouillage
Electro de verrouillage
Plateaux à encoches pour le verrouillage électrique des leviers
Arbres portant chacun 33 cames
Contre-balai
Balai
Détail d'une des 33 cames

Fig. 4. — Section of the Descubes locking frame with all-electric interlocking.

*Explanation of French terms:*

Arbres portant chacun 33 cames = Shafts, each with 33 cams. — Balai = Contact. — Barres horizontales... entre elles = Mechanically interlocked horizontal rods. — Contre-balai = Back contact. — Détail d'une des 33 cames = Detail of one of the 33 cams. — Electro de verrouillage = Locking electromagnet. — Plateaux à encoches... des leviers = Notched discs for electrically interlocking the levers. — Tête de verrouillage = Lock dog.

— a position 1, in which the lever is locked in the direction 0 towards 3, if there is another route incompletely set;

— a position, 2, in which the lever is locked in the direction 3 towards 0 if the entering lever to the route has not been brought previously to 0;

— a position, 4, in which the lever is locked in the direction 0 towards 6, as long as the points included in the route have not been operated;

— a position, 5, in which the lever is locked in the direction 6 towards 0, until the stop indication of the « stop » signal has been duly controlled and the train has left the protected area.

### The preparation and setting up of a route.

We will assume, for example, that a leaving route No. 1 from C is to be set up. We have seen above that lever 1 had to be pushed in order to bring it from position 0 to position 3, then lever C had to be pushed to bring it from position 0 to position 6. The first result of this double movement is to bring about in the cabin what Mr. Descubes calls the « preparation of a route ».

Each pair of points in the area governed by the Descubes table is represented in the cabin by a group of two relays, one corresponding to its normal and one to its reversed position. These are the two « preparation » relays of the said points.

Each of these preparation relays can occupy two positions : the neutral position in which it remains as long as it is not concerned in the setting up of any route, and the route position which it assumes when it is called upon to set up a route.

All the levers in the operating and the preparation relays of a given zone are interconnected by a double-wire electrical system, called « preparation system ». This is inside the cabin and is arranged diagrammatically in accordance with the entrance and exit roads and the point locations in the controlled area.

The November 1st, 1936, issue of the *Revue Générale des Chemins de fer* contains a description of the mechanism of preparation. The article indicates how the « calling current » sent out by lever

1 in position 3 through the outward preparation wire is returned as a « reply current » over the return preparation wire through lever C in position 4. It also describes the conditions under which, as the current flows, the preparation relays corresponding to the point positions ensuring the continuity of passage from C to 1, assume their proper route position.

Now that the route 1 from C has been set up in the cabin, it remains to be set up in the field. The reply current is reflected by lever 1, which sends it out as an « operating current » in a third circuit, passing through all the preparation relays concerned in the route. The operating current can only pass through this circuit if the relays are actually in their route position.

It then energizes a certain number of special relays, called point operating relays, which determine that the points ensuring the continuity of the route and, if necessary, the points ensuring its safety, are placed in the proper position, provided they are not already in that position.

The above way of preparing the route avoids the setting up of conflicting point positions.

To avoid routes crossing each other, the preparation relays are electrically interlocked by so-called « crossing-interlockings » (enclenchements de traversée).

If there are several routes leading from one end of a station side track to one end of a line side track, these various routes can be used or not.

In the first case it will be necessary to duplicate or triplicate the station side lever or line side lever, or even both in some instances. In the second case, a « diverted route interlocking » is made between the preparation relays.

### Control of a route and clearing of the entering signal.

It is the entering lever (in our case lever C) that, in position 6, must clear the square signal giving access to the route.

All the conditions required for the protection of this movement must therefore be fulfilled and controlled before lever C can be moved from position 4 to position 6.

This is the reason why the lock of lever C maintains this lever in position 4 until it receives the current which, sent out by the leaving lever in position 3, cannot reach the entering lever unless all the required conditions have been properly fulfilled. Of these conditions the following are the most important :

1. Proper position of the points ensuring continuity and safety of the route;

2. Point tongues tightly against stock-rails;

3. Locking of point motors;

4. Locking home of the tongues of facing points at speed;

5. Stop indication of the two « stop » signals governing the entrance to the route from each end;

6. Where required, correct indication of the corresponding « outer » signals;

7. Absence of any kind of vehicle on the route between the two « stop » signals and at the places where its presence would affect the route.

To this end, the zone between the «stop » signals of the route ends is divided into a number of isolated track sections, joined together and generally including one pair of points each.

One normal control relay and one reversed control relay per pair of points are then installed in the relay room of the cabin (in more recent installations these two relays are combined in one);

One relay for controlling the « on » position or the red lights display is also installed per « stop » signal; also

One track relay (or a repeater of this relay) per track circuit.

Finally, each route end is provided with a « transit relay » which is ener-

gized if there is no vehicle in the track circuit sections between the centre of the route and the end in question, and if — should this be the case — the track circuit sections of the neighbouring points are also free or if these points are so set that a crossing of the route is impossible.

The route control circuit is therefore closed when the following relays are actually energized :

Transit relay at both route ends;

Control relays of « stop » signal at both ends;

Point control relays ensuring continuity and safety.

The entering lever C is then released from position 4 by its lock, and brought to position 6, thus energizing the circuit which clears the « stop » signal giving access to the route.

### Cancellation of a route. Special devices.

As soon as a train has passed the entering signal to a route, the signalman must, in principle, return the lever of origin C to position 5.

This movement confirms the stop indication of the entering signal if the latter is put to stop automatically by the first or last pair of wheels of the train, or it causes the signal to go to stop if the above is not the case.

However, it should be impossible to cancel the route 1 from C unless the train movement requiring its cancellation has completely cleared the track between the two « stop » end signals (route locking).

Lever C is then unlocked from position 5 by the control circuit. The signalman brings it back to the neutral position and subsequently cancels the entire route by returning destination lever 1 to its neutral position (the preparation system having been so arranged that by returning lever C, then lever 1, to the neutral position, the point control relays included in the route, and subsequently their preparation relays, are returned to the neutral position).

Where traffic is heavy it is sometimes impracticable to wait until the second portion of a route (half-route locking, exit side) is entirely cleared to cancel this route and immediately to set up a new route having a common part with the first portion of the previous route.

A so-called « automatic cutting device » [1] is installed at the junction of the two portions of the route.

Experience has shown that in boxes dealing with heavy traffic it is very useful to assign on certain roads, to the zone controlled by the box, a limit which the signalman may adjust arbitrarily. Certain movements that should have been deferred or that would have delayed other movements can thus be carried out at any time without causing any disturbance.

This result is obtained by means of the so-called « shortened route » device [1].

### Illuminated diagram.

An illuminated panel representing schematically the track layout and point locations of the controlled area provides the signalman with all the information he needs to carry out his duty correctly. It shows :

Miniature signals displaying exactly the same indications as the corresponding signals observed by the drivers;

Red light indications for occupancy of certain particular track circuits (platform sidings, dead-end sidings, engine sidings, etc.);

Purple light indications for occupancy of the block sections outside the cabin area;

Green light indications for lockings between cabins or repetition of certain routes set up by neighbouring cabins;

While a route is being set up it is re-

---

[1] See November 1st, 1936, issue of the *Revue Générale des Chemins de fer.*

peated in white on the illuminated diagram. The light is extinguished when the point and route locking control indications are obtained.

In case of a point failure the light remains alight from the end of the route up to the faulty points so that the latter are known at once.

When a train enters a set route each half of the route is illuminated in white as the tracks are occupied by the train.

### Current supply sub-station.

In the route lever type cabins of the Descubes system, sub-stations produce the direct current (24-volt and 110-volt) by means of converter or rectifier sets and batteries. This current feeds :

— at 24 volts, the internal circuits (preparation, control, continuity, route locking, etc.), the point control and signal control circuits, locking circuits, track circuits, etc.;

— at 110 volts, the point operating circuits and, in the case of mechanical signalling, the operating circuits of the signal motors.

These sub-stations also produce, through successive stepping down, the low-voltage alternating current feeding the signal lamps where daylight signal panels are used (usually 5.7 volts) and the miniature lamps on the illuminated diagram (10 volts in cabins built before 1935, 24 volts in more recently installed cabins).

They are provided with standly plants in case of supply failures.

### The use of Descubes power boxes by the Est Railways.

At the present moment there are on the whole of the Est Railways eighteen interlocking cabins wherein the Descubes system has been installed. This figure may seem small, but it should be borne in mind that a number of these boxes are so-called « central » or « single » boxes, each controlling the whole of the signals and points of a station. Therefore, each of these boxes replaces two, three or even four « zone » boxes.

The above mentioned eighteen power boxes are installed at Bar-le-Duc, Baroncourt, Belfort, Blainville, Châlons, Charleville, La Villette, Lérouville, Lunéville, Nancy, Neuves-Maisons, Paris-Est, Reims and Vaires. They all contain all-electric locking frames.

Among these boxes No. 1, at Paris-Est (fig. 5), is the most interesting one on account of the number of functions operated and the complicated problems to be solved.

This box was built as an extension to the centre piers of the La Fayette bridge. It controls the whole of the station proper, i.e. 233 pairs of points and 180 colour light signals between the platform ends (31 roads) and the northern end of the Philippe-de-Girard arch (9 roads).

The layout is divided into five independent zones :

— the western main-line zone (10 platform tracks) used chiefly for the arrival and departure of main-line trains;

— the western suburban zone (6 platform tracks) and eastern suburban zone (6 platform tracks) for the arrival and departure of suburban trains;

— the eastern main-line zone (8 platform tracks) used chiefly for the arrival of main-line trains, plus one shunting siding (track 31);

— the northern zone, extending from the northern end of the Aqueduc bridge to the right-hand end of the Philippe-de-Girard arch.

For each of these sections there is a locking frame with route levers of the Descubes type and an illuminated diagram, but since these sections have certain common route ends, interlockings have been arranged to avoid conflicting movements.

Moreover, in the suburban zones

Fig. 5. — Power box No. 1 at Paris Est. — Interior view of control cabin.

shortened route ends have been provided in order to release more quickly engines which have brought in a train, and allow them to head another train ready to leave.

The control frames of box No. 1 include a total of 187 levers, of which 164 are used to set up 1875 complete routes and 34 shortened routes (each of these routes can be run over in both directions, making a total of 3818 routes) and 23 levers for individual signal or point operations or for interlocking :

Box No. 1 at Lérouville is noted for the extent of the area controlled, and the speed of the trains that run through it. The cabin is of the elevated type (the floor of the control room is 11.50 m. (36' 9") above ground level). The controlled area extends over a stretch of 5 030 m. (5 500 yards) between end signals :

— Paris end : the farthest signal is located at 2 030 m. (2 220 yards) from the box; the farthest points at 1 000 m. (1 100 yards);

— Avricourt end : the farthest signal is located at 3 000 m. (3 280 yards) from the box; the farthest points at 1 830 m. (2 000 yards).

The single locking frame in box No. 1 includes only 67 levers. It sets up 248

routes and operates 4 groups of apparatus totalling 98 pairs of points and 70 day-light signal panels.

**The semi-autonomous power frame.**

The principle of the electric power boxes with route levers consists in concentrating in the cabin the individual operation and control of each pair of points and signal. A large number of conductors is therefore necessary to connect the interlocking frame with the signals and track appliances in the field; the already considerable expenditure in connection with the laying of these conductors is still increased by the safety measures that are necessary to avoid contacts between wires, and earthing, causing failures and current losses. This expenditure is warranted in areas with heavy traffic, as there is a compensation in the large number of possible routes and the safety of the controls given to the signalman, but it is excessive in the case of small cabins with but few routes, or if these cabins are only used occasionally, as for instance, if they are located at simple junctions on the open line.

The search for suitable means to avoid these drawbacks and still maintain the possibility of controlling isolated routes from « any distance » led Mr. Vinot, Engineer, Head of the Traffic Research Department of the Est Railways, to design the « semi-autonomous power box » known as P. S. A. (poste semi-autonome).

The principle is as follows :

The P. S. A., situated near the points and signals to be operated, includes a certain number of devices called « route blocks », or B. I. (blocs itinéraires), each of which corresponds to the route that may possibly be set up. The B. I.'s are so designed that to operate them it will suffice to give them an initial impulse, either by pressing a local push button or by means of a remote control device. Once this impulse has been given, the following operations take place « automatically », each operation depending on the preceding one :

*(a)* Verification that nothing prevents a route being set up;

*(b)* Operation of the points for setting up this route;

*(c)* Clearing of entering signal.

The local control takes place in three stages, as follows :

*First stage.* — A push-button is pressed; providing all the safety conditions necessary for the setting up of the route are fulfilled, this energizes a relay storing the control (1);

*Second stage.* — This relay sends out to the motors the current necessary to put them into the desired position.

*Third stage.* — When the points have taken up the correct position, and this condition has been verified, the entering signal is cleared.

By pressing a second push button, called cancelling push button, the entering signal is put to « stop » and the storing of the route control is cancelled.

**Remote control.**

This system is easily adapted to control from any distance.

Assuming, for instance, that the area to be controlled by a specific cabin includes, say, four routes, the P. S. A. has four route-blocks, the local control of which is ensured by eight push buttons, namely, four operating push buttons and four cancelling push buttons. The remote control could be obtained by means of these same push buttons, by carrying them to the desired point and connecting them by so many wires to the corresponding terminals of the route controls. Since safety is fully ensured

(1) For details concerning principles and practice of the P. S. A., please refer to the August, 1935, issue of the *Revue Générale des Chemins de fer.*

by the interlockings and arrangements among and within the route controls, breakages in, and crossings between, these eight wires would have no dangerous consequences. But this can be improved upon :

— by having a single push button for the whole installation instead of eight local buttons, this single button being in series with an 8-way commutating switch, each contact stud of which would be connected either with the control terminal of one of the route-blocks, or with its cancellation terminal. To carry out a movement it would suffice to turn the switch onto the desired contact stud by hand, and then to press the single push button.

For the remote control of the semi-autonomous frame, this switch is replaced by a remotely controlled connecting device built on the same principle.

It is sufficient, therefore, to connect the « semi-autonomous » frame with the signalman's cabin by means of a control line permitting the necessary control impulse, and a selecting device, i. e. to have this control line end at the route-block to be operated. All that is required are two transmission lines, one for the selection of the route-block, the other for the transmission of the initial impulse. These two lines may be bare overhead wires, similar to telephone or telegraph lines. The signalman only has in his cabin the apparatus sending out the impulses for the operation of the connecting device and the single control push button.

### Controls and interlockings.

After setting up a route, the signalman must receive some form of confirmation or assurance that the movement has been carried out properly. To this end, the control push button in the upward position cuts the operating circuit and closes a control circuit ending in an indicator. The clearing of the entering signal causes the return current to go

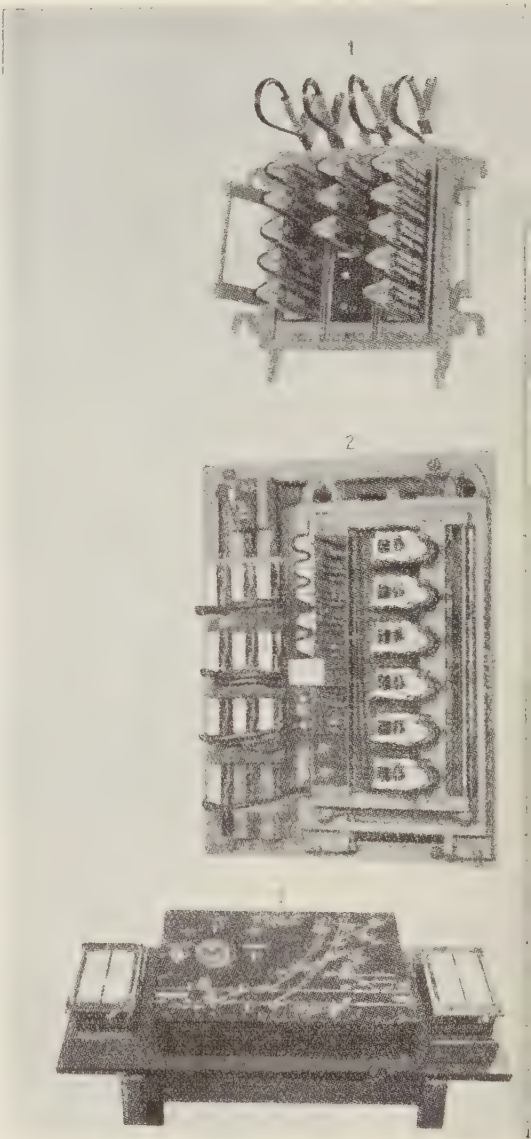



Fig. 6.

1. Route-block (B. I.).
2. Connector.
3. Control table in semi-autonomous box No. 3 at Belfort.

through this control circuit and the indicator to become visible.

— After he has set up a first route and ascertained by the indicator that this operation has been effectively carried out, the signalman can set up another route which is not conflicting with the one already set up, by connecting the operating line with another route-block.

The route-block, or route control, as it is realised to-day (fig. 6) is not quite as simple as the above description would lead to believe. It is, in fact, advantageous to concentrate in this device the largest possible number of operations, so that the wiring be carried out simply by connecting the control and operating wires to its corresponding terminals.

Thus the safety conditions are carried out by three relays, whose contacts connected in series control, respectively :

1. If conflicting route-blocks are normal ;

2. If the route to be set up is protected against possible conflicting movements;

3. If the route itself is free.

The protective device against conflicting movements is completed, if necessary, by an « approach locking » to take care of the following :

When a route has been set up and the signal giving access to it has been cleared, if the train has entered the section located between the extreme point of visibility of the outer signal and the stop signal, the signalman should not be able to alter by himself the route so as to prevent the points being operated at too short a distance ahead of the train.

Should a change of route be absolutely necessary, the train guard or driver, after the train has pulled up at the stop signal and after telephoning to the signalman, cancels the approach locking by pressing a push button installed in a case near the signal.

### Clearing of the entering signal.

The clearing circuit of the entering signal is governed by the above mentioned locking. This signal, which is already set automatically to danger by the occupancy of the route, also goes to « stop » automatically if a conflicting route-block is energized accidentally or if the locking preventing conflicting movements fails.

In principle, when the signal has gone to « stop » automatically, it can only be cleared after the route has been cancelled and re-set. This condition may become inconvenient when several successive trains following each other at very short intervals must use the same route.

An additional device called « permanent-route block » is then used, which is remotely operated in a similar manner to the B. I. When this device is operated, the entering signal functions as an automatic block signal, that is, it clears by itself after the passage of each train as soon as another train can be admitted.

Finally, a route-block may be so designed that it is de-energized automatically as soon as the train has left the controlled area.

### Impulses and codes.

The following is used for the transmission of impulses :

— either a numbered dial similar to those used in automatic telephone systems;

— or a device having a pointer moving in front of a series of code numbers, and a lever sending out the impulses corresponding to the code numbers to which the pointer is moved.

The code numbers are usually two-figure numbers and the connector has two tiers of rotary switches, each rotary switch having five rings used to ensure the operation of the device and to make the connections for carrying out the various operations (fig. 6).

After sending out the code number, the signalman presses the control push button, which causes the operating contact to make and to cut the control contact. A bell indicates to the signalman that the operation is complete. He then releases the push button (which returns automatically) and makes the control contact. The return current emitted by the clearing of the entering signal of the route can thus cause the black of the indicator to appear.

The setting up of a route (sending out of the code number, operation and control) takes 10 to 15 seconds.

The movements effected by the signalman are controlled, in principle, by means of an illuminated diagram showing the track layout and on which translucent lines are illuminated when the operating current reaches a route control. These lines remain illuminated until the route is cancelled.

Independently of route setting and cancellation, the remote control system of « semi-autonomous power boxes » permits the carrying out, through suitable codes, of various accessory operations, such as :

Remotely putting to stop or clear of certain signals;

Checking the clearing of certain track circuit sections;

Calling linesmen or shunters on the telephone;

Remote re-interlocking of circuit breakers located on certain electric circuits, feed circuits of point machines, etc.

### Special devices.

In principle, when a route can be used for both directions, it should be provided with two route-blocks : one for the normal direction of traffic and one for the opposite direction, to provide for the clearing of the opposing signal.

In order to reduce the number of route-blocks, one route-block only is used in this case but a « discriminating » auxiliary relay called « holding up » relay is used.

The route-block then controls the points and the holding-up relay determines the clearing of one or the other of the signals at the route ends, depending on whether this relay is de-energized or energized. The « holding up » relay is operated by a special code.

The number of route-blocks can also be reduced if certain routes have a common point. Each one of these routes is then divided into two portions joined at this point, and the routes in question are set up by operating the two portions successively, first the leaving end, then the other.

Finally, if necessary, the semi-autonomous boxes are provided with a device called « shortened-route » device whose function is similar to that of the same device in the Descubes type power boxes.

### The semi-autonomous power boxes on the Est Railways.

The first installation on the Est Railways was put in service on the 25th April, 1934. It includes the operation from Onville station (i. e. from a distance of approximately 4 km. or 2.5 miles) of two double-track junctions ensuring the connection of a 1 700-m. (1 860 yards) branch with two heavy-traffic lines (8 route-blocks and 2 connectors).

There is a simpler installation at Baroncourt (27th March, 1935) were the central cabin controls the duplicate line from Audun-le-Roman from a distance of approximately 2 000 m. (2 185 yards).

The semi-autonomous power box No. 3, at Belfort (15th November, 1934), is much more complicated. It controls an area comprising 13 sets of points, including a double track junction, a communication track to the marshalling yard, and a mass of cross-overs and

shunting sidings, etc. The routes are repeated on the illuminated control panel.

Finally, at the Paris end of Lagny-Thorigny station, an area similar to that at Belfort as regards importance and complexity (13 pairs of points) is operated from a distance of approximately 600 m. (655 yards) by the central electric box at Lagny.

The May 1937 issue of the *Revue Générale des Chemins de fer* contains a description of this semi-autonomous box, called « P. S. A. No. 1, Lagny ».

The semi-autonomous boxes we have just dealt with, although very different as regards size and amount of traffic controlled, operate regularly and very satisfactorily.

The savings in operation effected with these cabins will allow the Railway to amortize the initial expenditure for these installations in a few years.

The signalmen have adapted themselves without difficulty to the new system, despite the fact that having to control remotely an area completely invisible to them might have seemed confusing at first.

## Conclusion.

The interlocking cabins of the Descubes type and semi-autonomous cabins of the Vinot type, the principles of which were conceived by engineers of the Est Railways, are designed, built and put into service by members of the Est Railways staff, who have also prepared the plans and drawings for the manufacture of the majority of the apparatus used.

Experience has shown that the results achieved with these power boxes were fully in accordance with expectations. They are equipped with the most modern safety devices and occupy in the signalling and interlocking world a place of which the Est Railways may justly be proud.

# MISCELLANEOUS INFORMATION.

[ 621. 43 & 625. 251 ]

## 1. — The N. R. self-adjusted brake,

by V. NICOLET, Ingénieur en chef, and R. ROUSSELET, Inspecteur de la Traction de la Région de l'Ouest, French National Railways Company.

(From *Traction Nouvelle*.)

In order to obtain the minimum stopping distances when braking a vehicle, by applying friction materials to the tyres of its wheels or to drums mounted on its wheels, it is necessary to apply this friction at any time with the highest possible pressure which will not cause any locking or in other words, it is necessary alway to remain slightly below the limit of adhesion of the wheel on the rails.

As a matter of fact, as soon as locking of the wheels takes place, the coefficient of friction obtained at that particular moment, which in theory is equal to the co-efficient of adhesion just before locking sets in, will be very rapidly reduced on account of the polishing of the friction surfaces; the retardation effect being reduced in proportion, the stopping distance will be increased in a corresponding manner. In addition, the friction on locked wheels will have very bad results such as « flats » on the wheels of a railway vehicle, which will increase the noise during the running, and even lead to destructive vibrations; tearing off the rubber on rubber tyres, which may result in a tyre burst at a later date, apart from the fact that, for a motor vehicle, locking of the wheels is definitely dangerous as the steering of the vehicle will be more or less neutralised and, on a wet road surface, some sensationnal sluing-round cases sometimes occur.

It is necessary, therefore, when examining the means of obtaining the best possible braking effect, to know the law of adhesion; we shall not deal in this paper with the motor-car on the road (see the paper by Mr. REDDON in the *Bulletin S. I. A.* of March, 1937, from which it would appear that for most road surfaces the adhesion will be reduced with increasing speed), and shall only consider the railway vehicle with metal tyres.

The law ruling the adhesion of the wheel on the rail has been very much discussed in the past and will be for a long time to come; if, in theory, there may be a definite law for a wheel assumed to be always equally loaded and running on an ideal rail (this law might for instance only consist in the adhesion being independent of the speed), in practice it will always be necessary to consider the braking problem in the light of what might be called the law of available adhesion. As a matter of fact, adhesion for one and the same speed varies :

(1) According to the state of the rail, whether it is polished or rusty, hot or cold, dry, wet, clean or greasy, and finally whether sanding takes place or not during the brake application;

(2) With the length of the rail (influence of rail joints) ;

(3) With the nature of the track and its maintenance : weight of rail per foot length; number of sleepers per unit length; state of the ballast; setting out of the curves with a more or less pronounced superelevation; these being all factors affecting the bending of the rail under the load of the wheel.

(4) With the arrangement of the suspension of the vehicle, but in our paper we will assume the quality of the spring gear to be constant.

All the conditions under (1), which vary at

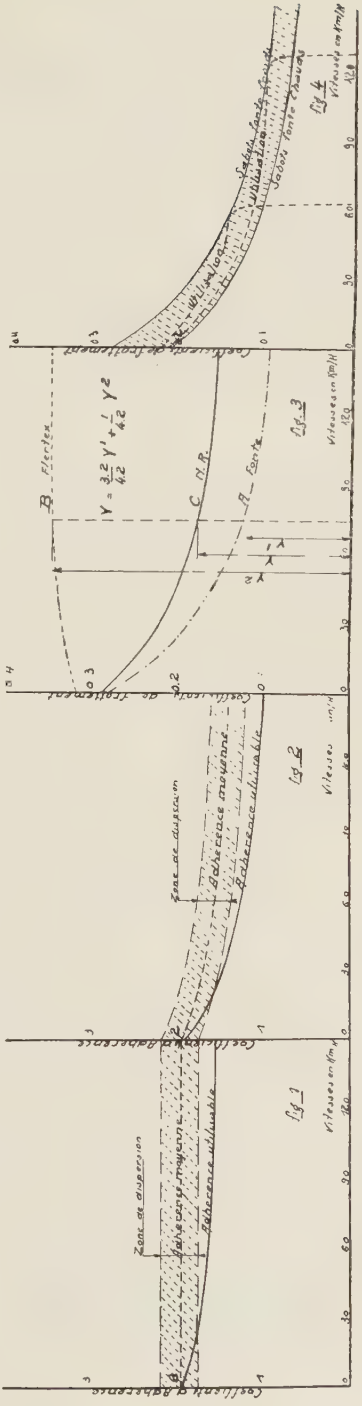
any moment for a given track, lead us to consider a curve of average adhesion, dependent on the speed, the values for this curve being within a band of a certain area above and below this curve.

The shape of this curve will vary according to the state of the track as mentioned in (2) and (3). In Germany for example, METZKOW, following very severe tests carried out under certain definite conditions — rails welded in lengths of 60 m. (197'), laid on a perfect formation, and speed restricted to 60 km. (37.3 miles) an hour — obtained a practically straight line (fig. 1) as the curve of average adhesion, whereas for tracks of average condition, having rails from 12 to 18 m. (39' 4" to 59') long, the adhesion is generally assumed to drop with the speed (fig. 2). This is easily understood if one considers that a vehicle running at a higher speed is more jolted on account of the defects of the track and of the rail joints being at a shorter distance of each other within the same period, and a braked wheel will, therefore, be subjected to alternating positive and negative loads of greater intensity and frequency, and will be far more easily locked.

Be that as it may, the available adhesion must take into account that locking at high speeds must be avoided under any circumstances, because its effects would then be very destructive, whereas locking at low speeds will not have sufficient time over a distance of some tens of metres to produce a real flat.

Under these circumstances, it is imperative at high speeds for the curve of available adhesion (see figs. 1 and 2) to be outside the dispersion zone, and to coincide with the average adhesion point, with speed nil.

It is necessary, therefore, to obtain, with the available friction materials, effects which will approximate as much as possible this curve of available adhesion during brake applications. The materials used up to now for this purpose are either cast iron or some asbestos material, variously impregnated and generally called ferrodo. The laws of friction of these materials on the steel tyres of the wheels or on drums mounted integral with the wheels have been studied in laboratories




*Explanation of French terms:*

Coefficient d'adherence = coefficient of adhesion. — Zone de dispersion = dispersion zone. — Adherence moyenne = mean value of adhesion. — Adherence utilisable = available adhesion. — Vitesses en km./h. = speeds in km./h. — Coefficient de frottement = coefficient of friction. — Fonte = cast iron. — Sabots fonte, froids (chauds) = cast iron shoes, cold (hot). — Utilisation = range of use.

and are shown in figure 3 (curves A and B). These show that if the pressure of application of the friction materials remains constant during a brake application it is necessary, with cast iron, for this pressure to cause locking only for a speed equal to zero, whereas with ferrodo the pressure should be such as to approximate locking at the maximum permissible speed. In order to obtain the best possible brake application it is therefore necessary, when using only one of these materials, to vary the pressure during the application, reducing it for cast iron and increasing it for ferrodo, in a measure as the speed drops.

It should be noted that whereas the co-efficient of friction of ferrodo varies little with the temperature, that of cast iron varies considerably and is much lower at high temperature than when the brake block is cold. In order that the maximum possible brake force should not cause any locking it is necessary to base the calculations on the highest value of the co-efficient of friction, that is to say to consider in this connection the friction curve for cold brake blocks.

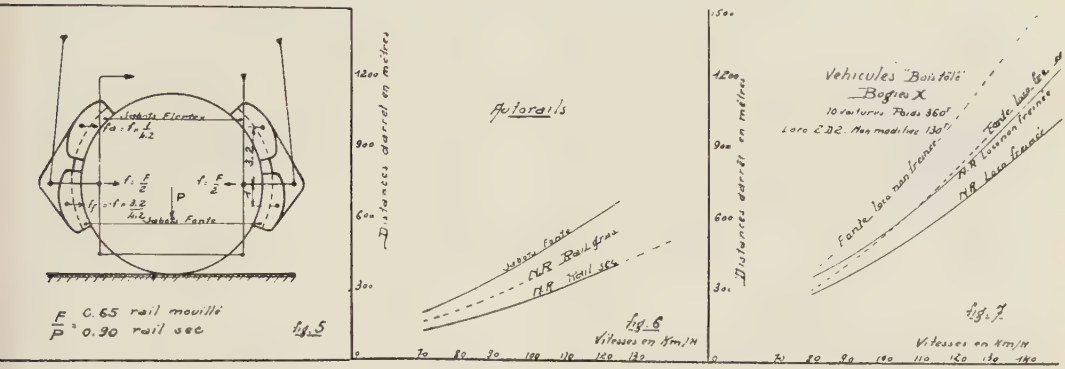
Of course when applying the brakes at a constant pressure, the values of the co-efficient of friction will start from the cold brake block curve and will ultimately merge into the hot brake block curve (fig. 4); that is why the wheels of certain vehicles having an excessive braking ratio will not lock at all during an emergency application from a high speed, but will lock regularly as soon as the brake blocks are applied during a brake application with the same pressure but at low speed. This also explains the advantage of double brake blocks with which the curve of the co-efficient of friction (with same braking pressure), will remain nearer the cold brake block curve, as not only will their temperature remain at a lower value, but they will also cool off more rapidly.

For cast iron different types of so called self-adjusting devices have been designed in order to make the pressure vary with the speeds. They are generally based on the operation of valves by means of centrifugal regulators connected to the axles. It would not appear that any attempts have yet been made to vary the braking pressure for ferrodo. This would not appear to be so necessary because, as the horizontal section of the curve for the co-efficient of friction of this material approximates during a considerable period the curve for the available adhesion which flattens out at high speed, it is possible to obtain shorter stopping distances at speeds exceeding 110-120 km. (68 to 75 miles) an hour with a ferrodo brake than with a cast iron brake shoe, if both are applied with the same pressure. It will, of course, be immediately noted that there is a greater danger of locking the wheels at high speeds with a ferrodo brake than with a cast iron brake. On the other hand it should not be overlooked that ferrodo wears very rapidly at higher temperatures; therefore with a high braking pressure, and if comparatively heavily loaded wheels are braked with this material, the tyres or drums will wear very rapidly, not to mention the impossibility of dissipating the excessive heat.

The N. R. type of brake has been developed in order to make the best possible use of the qualities of the two braking materials which complete each other, and calculations which have been verified by means of tests show that if the total braking pressure required is divided in a 3.2:1 ratio between the cast iron block and the ferrodo block, the best results are obtained for maximum speeds of 120 to 140 km. (75 to 87 miles) an hour. It is right, therefore, to call this type of brake « self-adjusted », as the co-efficient of friction at constant pressure is as shown by curve « C », figure 3.

As the distribution of the braking between the two types of brake block is defined by the fact that curve « C » is similar to the curve of available adhesion, the ratio between the two types of brake-block will give the necessary braking coefficient.

The braking ratio will be 65 % if adjusted for a wet rail, and may be as high as 90 % for a dry rail, these values being nominal as they do not take into account the efficiency of the rigging. The force acting on the rigging is therefore always less than the tare




Figs. 5 to 7.

*Explanation of French terms:*

Autorails = railcars. — Bogies X, 10 voitures, poids 360 t. = X type bogies, 10 carriages, weight 360 metric tons. — Distance d'arrets en mètres = stopping distances, in metres. — Fonte (N. R.), loco. non freinée = cast iron (N. R.), locomotive not braked. — Fonte (N. R.), locomotive freinée = cast iron (N. R.), locomotive braked. — Loco 2 D 2 non modifiée, 130 t. = 2 D 2 locomotive, not modified, weight 130 metric tons. — Rail mouillé = wet rail. — Rail sec = dry rail. — Sabots Flertex = Flertex-lined shoes. — Sabots fonte = cast iron shoes.

of the vehicles, whereas with self-adjusted brakes fitted with cast iron blocks it is necessary at high speeds to have braking efforts as high as 180 % of the tare, so that very heavy riggings are required, which in many cases can only be mounted with difficulty. Figure 5 shows the arrangement of the brake blocks on a wheel : the ferrodo brake block is always above the cast iron brake block and will therefore have a constant co-efficient of friction because, in the case of wet rails, the cast iron brake block will remove the water film (it is, of course, well known that the co-efficient of friction of ferrodo decreases when wet).

The first trials were made with levers making it possible to distribute the brake force on brake blocks of different materials. The results obtained were practically the same for distributions between 1:3 and 1:3.6 ratios; the ratio 1:3.2 has been adopted, because it has the advantage of an equal wear of brake blocks of equal dimensions for the materials under test.

Another quite important advantage noticed during the tests was the smooth and comforable emergency applications because the peak of deceleration which is so noticeable with the cast iron brake block at the moment of stopping is avoided and the deceleration remains practically constant during the braking period.

It is therefore possible, with a very simple installation and little maintenance and wear, to obtain a brake for railcars and high-speed trains, showing results that, all other things being equal, are at least as good as those of other more complicated types of brakes tried out up to now.

*Vehicles provided with N. R. brakes and results obtained in service :*

The first railcar was equipped in October 1936. Since then, ten Renault V. H. type railcars, four Renault A. B. J. type railcars, two Dietrich railcars and five Renault A. D. P. type railcars, have been equipped with this type of brake and have run up to the present 1 200 000 km. (without any hitch). A two-way valve having two positions corresponding to either dry or wet rail makes it possible to obtain the best possible brake applications in both cases without any danger of the wheels becoming locked.

On the other hand, a set of 10 bogie wooden carriages has been fitted with this brake and undergoing tests, being hauled by a 2-D-2 electric locomotive which had not been modified, that is to say having a braking ratio of approximately 60 % of the tare weight.

The results of these tests are shown in the curves of figures 6 and 7. On a dry rail, stopping distances of 380-400 m. (1 245'-1 300') are obtained for railcars, from speeds of 120 km. (75 miles) an hour, which is practically the same value as that obtained with the different types of self-adjusted systems tested up to now; but when so adjusted the latter will cause locking of the wheels on wet rails.

On the other hand, with the set of 10 carriages, stopping distances of 900 m. (2 950') were obtained from speeds of 140 km. (87 miles) an hour, whereas for the same train composition, using cast iron brake blocks but having an excessive braking ratio (which caused a considerable number of « flats »), stopping distances of 1 100 m. (3 600') from speeds of 140 km./h. were obtained with the same 2-D-2 type of electric locomotive. It should be noted, however that in order to equalise the braking coefficients, or the « braked weights » (30 % higher with the N. R. type of brake) of carriages having different tare weights, additional reservoirs have been provided, connected to the brake cylinders, with a coresponding increase in the cylinder filling periods, the effect of which is to increase the stopping distances from a speed of 140 km./h. by approximately 60 m. (195'). In a final design, this would be avoided by a suitable alteration of the leverage ratios of the rigging.

*Future investigations in order to improve braking :*

As it would appear that almost full advantage has been taken of the available adhesion an endeavour should be made in the future to :

(1) Improve the available adhesion by means of suitable sanding. This requires efficient sanders, the driver being able to control the flow on the rails, and the quantity of sand remaining in the sandboxes.

(2) Increase the speed of propagation of the braking effect on long trains, which has already led to the manufacture of different types of apparatus abroad.

---

[ 625. 212 ]

## 2. — Fractures of railcar axles (*),

by Mr. CHATEL,

Engineer, Assistant Chief of Engine Workshops, Northern Region, French National Railways Company.

(From *Traction Nouvelle*.)

We know several countries where the extensive use of railcars with rotating axles of special steels has given rise to a certain number of axle fractures. In France some thirty fractures have occurred on three or four types of railcars, the axles of which have now been replaced by more robust ones. In no case have passengers or train staff been injured; as the French railcars have run a total of more than 100 million km. (over 62 million miles), the number of fractures is relatively low. A few axles broke before a distance of 60 000 km. (37 300 miles) had been covered, but the greater number of fractures occurred after a distance of between 60 000 and 120 000 km. had been run.

It is proposed here to analyse briefly the results — and state the conclusions which may be drawn from them — of the investiga-

(*) *Editorial note.* TRACTION NOUVELLE : This article expresses the personal opinion of Mr. Chatel on the question of fractures of railcar axles and does not necessarily involve that of the French railways. It gives no information on the measures taken by the French railways to eliminate these fractures as far as possible. Such considerations, indeed, had no place in an article of a personal nature.

tions carried out simultaneously by the Railways and by the Manufacturers, following these failures.

*Axle flexion.* — The first point which was noted regarding the axles of certain types of railcars is their relatively high flexion compared with that of carriage axles in carbon steel. In the case of solid axles of special steel having a breaking strength of about 100 kgr./mm² (63.5 tons per sq. inch), this flexion is due to the fact that, in order to save weight by utilising the high mechanical properties of the steel, the fatigue rate has been increased, since the diameter has been decreased, as also has the modulus of inertia.

This flexion which, under load, may reach 2 or 3 mm. (5/64" to 1/8") presents several drawbacks :

1. It necessitates special precautions when fixing the wheel centre on to the axle, in order to comply with the regulations concerning the distance between the tyres at rail level;

2. During running, the axle bends considerably as it rotates; and what is more serious, it gives rise, at critical speeds, to vibratory resonance.

The application of Föppl's formula for the calculation of the critical speed (1), with particular reference to the axles of the Renault ABJ railcars, gives a value corresponding to 108 km. (67.1 miles) per hour, whilst the normal speed of the vehicle often exceeds this figure. The danger resulting from excessive bending can thus be readily seen.

Moreover, secondary influences, such as shocks over rail joints and variations in the torque, can increase the calculated deflections and consequently decrease the critical speed; consequently the latter frequently coincides with the usual running speed and the coefficients of safety of two or three required by the builders of turbines is far from achieved. The result may be a slow destruction of the metal, cracks progressing more or less rapidly.

It may be mentioned that dynamic balancing of the axles can prove an effective method of reducing stresses. Up to the present this has not been put into practice in France, whereas it is general in England, even for locomotive straight axles. An investigation of this question now very much to the fore, has just been undertaken by the « Ateliers de Construction de Jeumont », and it is to be hoped that this will really contribute to the solution of the problem we are dealing with.

*Position of the fractures.* — In addition to the existence of a critical speed at which an excessive load is put on to the axle, bad design of the wheels and axles often leads to increased fatigue at certain well defined points. In fact, whilst several instances have been noticed where, with particularly flexible axles, the location of the fractures was not governed by any fixed law, they have generally occurred either level with the wheel seat or along a variation in section between two seatings (1).

When the wheel is pressed on to a wheel seat of the same diameter as the body of the axle, it is noted that there is a sharp stress increase in the sections along the ridges of the wheel boss. Moreover, the stresses may possibly be increased by a kind of strangling effect on the axle due to the elastic reaction of the wheel; this is one of the drawbacks of the monobloc type of wheel-centre, which has a great radial strength and is made of harder material than the axle. With such wheels it might be advisable to reduce the press-fit pressure.

Photo-elastic investigations carried out by the Timken research department at Canton, (Ohio, U. S. A.), have confirmed the existence of these stress concentration points, which appear very clearly on the left-hand photograph of the two reproduced below. These investigations have also shewn the desirability of providing stress relief grooves on the body of the wheel, and so avoiding harsh variations in

(1) $Nc = 945 \sqrt{\frac{\Sigma\ P_i F_i}{\Sigma\ P_i F_i^2}}$ r. p. m. ($P_i$ and $F_i$ being the force and the deflection in the section of index $i$).

(1) Accurate machining of the axle assists in reducing fatigue fractures.

the profile of the axle (see photograph on right). If this is done the points of stress concentration are greatly attenuated.

*Nature of the metal.* — It was naturally thought that the fractures might be if not caused, at least facilitated by poor quality metal. In this respect, however, none of the analytical tests made has even proved conclusive, except insofar as that the Ni Cr Mo, or Cr Mo only, steel has not been found defective, correctly speaking, from a metallurgical point of view. It must be recorded, however, that certain axles have been found to have been tempered at too low a temperature resulting in rather a low resilience.

Whatever degree of perfection be achieved in the composition of special steels, it will be found that whilst it may give a higher fatigue limit for rotary bending, it remains more susceptible to bending than carbon steel, where there are variations in section. Systematic trials with test pieces similar to the axles have given, for Cr Mo steel a breaking point under rotative flexion of 20.7 to 23.5 kgr./mm² (13 to 15 Engl. tons per sq. inch), and for class G carbon steel of 60 kgr./mm² (38 tons per sq. inch) as used by the railways, a breaking point under rotary bending of 24 to 26 kgr./mm² (15.2 to 16.5 tons per sq. inch).

On the other hand, the determination of the fatigue limit for rotary bending on ordinary test pieces with constant section gave 38.3 kgr./mm² (24.4 tons per sq. inch) for Cr Mo steel, and 28 kgr./mm² (17.8 tons per sq. inch) only for class G steel after annealing. These results prove clearly that with the class G steel variations in section are of much less importance under rotary bending.

Moreover, during these trials, all the fractures in the models occurred in sections corresponding to those in which the actual fractures were actually experienced.

It must not be concluded from these tests, however, that a high fatigue limit is not desirable, but only that with special steels the margin between the theoretical fatigue limit and the breaking point under rotary bending is much greater when there are variations in section than is the case with carbon steels. It is therefore of value to provide special steels with a much higher fatigue limit; this has been done by such builders as Messrs. Renault, who have used a Ni Cr Mo steel of 62 kgr. (39.4 tons per sq. inch) fatigue value for the axles of their new railcars.

*Examination and location of the cracks.* — Owing to frequent failures with railcar motor axles on secondary lines, the Reichsbahn set up two testing plants at Limbourg, in an attempt to throw some light on the failures.

1. An electric test plant, which shews variations in resistance of a fissured axle inserted in an electric circuit which includes a millivoltmeter. This method will give the location of the flaw only when special precautions are

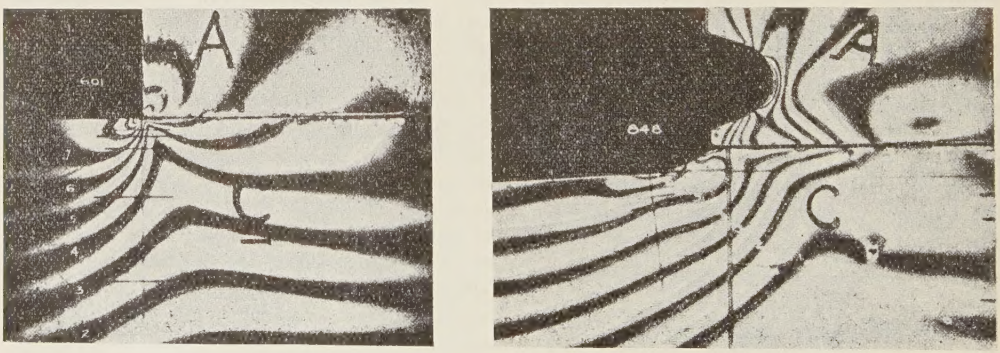



Photo-elastic study obtained by the Timken Research Department, showing the distribution of stresses.
A : Wheel centre. — C : Wheel seat.

taken, and cannot easily be arranged to shew their size.

2. A magnetic test plant, with which the suspected axle is inserted in a high-induction magnetic circuit (coil of 3 200 ampere-turns). The cracks appear clearly when the axle is sprinkled with iron filings.

This method, which does not allow of the detection of non-apparent flaws, particularly those inside the wheel seat, does not appear to be a great advance on the current practice of examination by means of whitewash.

Only the electric plant, which is both costly and delicate, would appear to be of value for the inspection of railcar axles.

*Calculation of the axle.* — In order to have the maximum guarantee, when calculating axles it is desirable to take into account all the forces brought into play, which may be summarised briefly as follows :

1. Static loads, made up of :

— load on the boxes; unsprung weight.

2. Braking forces, comprising :

— a horizontal tangential force equal to the adhesive power and applied to each wheel;

— a transverse force due to the inclination of the tyres.

3. Starting forces, i. e. :

*(a)* the tangential effort on the driving pinion;

*(b)* the transverse effort due to the inclination of the tyres;

*(c)* the tangential effort applied to the periphery of the wheel and corresponding to the torque;

*(d)* the axial reaction due to the couple acting on the coned tread of the tyre;

*(e)* the action of the torque on the splined shaft;

*(f)* the torsion under the torque.

4. Forces exerted when running at maximum speed.

To the foregoing forces calculated for the torque at maximum speeds must be added the following dynamic forces :

*(a)* Forces due to vertical accelerations (0.4 of the spring-borne weight).

*(b)* Forces due to hunting; these are taken as equal to 0.4 of the weights and applied to the centres of gravity of the body for its weight, of the bogie for its spring-borne weight, and to the axis of the axle for the unsprung weight. The component of these three forces will be applied to the wheel flange.

*Conclusion.* — When the sensibility of special steels to alternated stresses is taken into account, it will be seen that prudence is necessary in the acceptance of the calculated stresses for axles; these fatigue factors ought not, for example, to exceed twice those now accepted for carbon steel axles.

The modulus of inertia can then be halved, and a simple calculation shows that the ratio of weight for axles of special steel and of carbon steel is around 0.65. The use of special steel therefore gives a saving in weight of approximately 35 % only — or at most 400 kgr. (880 lb.) for a railcar, taking into account the saving on the boxes.

Bearing in mind the cost of axles of special steel, at least 80 % higher, it is desirable, in our opinion, to return to the use of carbon steel for the axles of ordinary railcars.

For high-speed railcars a satisfactory solution would seem to be a hollow axle of special steel, which would give a higher modulus of inertia for the same weight, subject of course to its being bored with great care, and attention, the following precautions being taken :

*(a)* full calculation, with a safety factor of at least two over the breaking point under alternated bending, as shown by reduced-scale models;

*(b)* stress relief grooves on the wheel bosses;

*(c)* lower press-fit pressure of monobloc wheels;

*(d)* careful profiling of the axle, eliminating all sudden changes in section;

*(e)* as even a distribution as possible of the torsional stresses on both sides of the driving pinion.

# NEW BOOKS AND PUBLICATIONS.

[ 625.1 (.56)

**The construction of the Irmak-Fylyos and Favzipasa-Diyarbekir railway lines.** *Work carried out by the Swedish-Danish Syndicate,* 1927-1935. — A volume (12 × 9 inches) with many illustrations and 46 inset plates — 1937, Göteborg and Copenhagen; published by Nydqvist & Holm A.B., J. Saabye & O. Lerche, and Kampmann, Kierulff & Saxild A.S.

This book, published by the above firms, who supervised the construction of, and supplied the rolling stock for, the Turkish railways in question, of a total length of 826 km. (513 miles), contains information on the history of these railways and a close description of the actual layout, together with a comparison of the alternative layouts considered, and the reasons for the selection of that actually adopted.

It also contains descriptions of the projects carried out of different structures, and, what is of particular value from both the technical and economic points of view, a special table by means of which it is easy to calculate clearly and without difficulty the unit prices of the more important works involved in building a railway, such as earthwork, masonry, concrete work, and tunnels, is included in the chapter on the estimates.

Valuable data are given about the amount of constructional work of various kinds carried out. As these relate to contracts for different and generally short lengths (19.2 km. = 12 miles) on the average, it is possible to get a very accurate idea of the constructional work carried out under various conditions. The chapter devoted to these works includes a list of the actual unit costs.

A description of the sanitary work undertaken is also given, and statistics about the care of sick and injured employees. Finally exact details of the rolling stock supplied are also given.

The text is printed in both French and Danish so that it will be available to a great many specialists and may be of great service to those engineers who have to draw up schemes, and supervise the construction of railways and roads in new countries.

The book has been skillfully edited and is copiously illustrated. It may be said that no such work has appeared in the technical literature since the pamphlets on the Albula railway and the Lake Constance-Taggenburg-Lake Zurich line.

The only criticism that may be made is that the diagrams showing the gradient section of the lines have not been drawn with sufficient detail.

P. KANDAOUROFF.